GRAU EN CIÈNCIES I TECNOLOGIA DE LA EDIFICACIÓ

TREBALL DE FI DE DE GRAU

ANÀLISI DEL CICLE DE VIDA (ACV) DELS MATERIALS DE LA CONSTRUCCIÓ

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Resum:

En aquest treball final de grau s'exposa el treball realitzat durant un any de practicas en la institució ITeC sobre l'analisi del cicle de vida dels materials de la construcción.

El treball s'estructura en dues parts molt diferenciades, al principi introdueixo els conceptes amb la ajuda d'exemples, així com una breu introducció retrospectiva en la historia.

Després passo a explicar com s'ha realitzat el anàlisi, el que s'ha tingut en compte, i algunes opinions personals un tema força desconegut pel sector.

Sense perdre de vista l'objectiu d'aquest projecte, que és la realització d'una base de dades ambientals que complementi l'actual base de dades de ITeC (BEDEC). Per a això, s'han realitzat més de 3.000 simulacions i càlculs per a l'obtenció dels indicadors ambientals.

L'abast d'aquesta base de dades realitzada, finalitza amb la producció dels materials primaris de la construcció, com s'indica en el nom del projecte. Aquest projecte que he realitzat, serveix per posar la base d'un inventari de dades.

Finalment, vull aportar les meves conclusions sobre la realització de les practiques.

Índex

GLOSARI:

Cicle de vida; CV:

Etapes consecutives i interrelacionades d’un sistema producte des de l’adquisició de matèries primes o la generació de recursos naturals fins la disposició final.

[ISO 14040:1997]

Anàlisi del cicle de vida; ACV:

Recopilació i avaluació d’entrades, les sortides i els impactes ambientals potencialment d’un sistema del producte a través del seu cicle de vida.

Anàlisi de l’inventari del cicle de vida; ICV:

Fase de l’anàlisi del cicle de vida que implica la recopilació i la quantificació d’entrades i sortides per un sistema del producte a través del seu cicle de vida.

Avaluació de l’impacte del cicle de vida; EICV:

Fase de l’anàlisi del cicle de vida dirigida a conèixer i avaluar la magnitud i quant significatius són els impactes ambientals potencials d’un sistema del producte a través de tot el cicle de vida del producte.

Resultat de l’anàlisi de l’inventari del cicle de vida; resultat del ICV:

Resultat d’un anàlisi de l’inventari del cicle de vida que classifica els flux que travessen els límits del sistema y proporciona el punt de partida per l’avaluació de l’impacte del cicle de vida.

Impacte mediambiental:

Qualsevol canvi en el medi ambient, sigui advers o beneficiós, resultant tot o part de les activitats, productes i serveis d'una organització.

[UNE-EN 14001]

Unitat funcional:

Quantificació de la funció d'un sistema del producte, des de l'adquisició de matèries primeres o generació de recursos naturals fins la seva eliminació final.

[ISO 14040:1997]

Producte:

Tot tipus de bens o serveis.
El producte es pot categoritzar com:

- Serveis (per exemple transport).
- Software (per exemple programes informàtics, diccionari).
- Hardware (per exemple part mecànica d'un motor).
- Materials processats (per exemple lubricant).

Residu:

Tot allò que no té ninguna utilitat pel generador o posseïdor y que és rebutjat o emès al medi ambient.

Categoria de producte:

Grup de productes que tenen una funció equivalent.

Característica funcional del producte:

Atribut o característica relacionada amb l'ús o funcionament del producte.

Aspecte mediambiental:

Element de les activitats, productes o serveis d'una organització que pot interactuar amb el medi ambient.
Un aspecte mediambiental significatiu és aquell que té, o pot tenir, un impacte mediambiental significatiu.

[UNE-EN ISO 14001]

Certificació:

Procediment pel qual una tercera part proporciona garantia escrita de que un producte, procés o servei es conforme amb els requisits especificats.

Matèria prima:

Matèria primària o secundaria que s'utilitza per elaborar un producte.

Entrada auxiliar:

matèria que entra i s'utilitza en el procés unitari de l'obtenció del producte, però que no constitueix una part del producte.

Coproducte:

Qualsevol dels dos o més productes que provenen del mateix procés elemental.

Procés:

Conjunt d'activitats mútuament relacionades o que interactuen, les quals transformen elements d'entrada en resultats.

[ISO 9000:2005]

Sortida:

Flux de producte, de matèria o energia que surt d'un procés unitari.

Energia de procés:

Entrada d'energia requerida en un procés unitari, per dur a terme el procés o fer funcionar l'equip, excloent les entrades d'energia per la producció i subministrament de aquesta energia.

Sistema del producte:

Conjunt de processos unitaris amb flux elementals i flux de producte, que exerceix una o més funcions definides, i que serveix de model pel cicle de vida d'un producte.

Flux elemental:

Matèria o energia que entra al sistema que s'estudia, que a sigut extret del medi ambient sense transformació prèvia per l'ésser humà. O matèria o energia que surt del sistema que s'estudia, que es alliberat al medi ambient sense transformació posterior per l'ésser humà.

Flux d'energia:

Entrada o sortida d'un procés unitari o un sistema del producte, expressat en unitats d'energia.
El flux d'energia que entra es pot denominar entrada d'energia; el flux d'energia que surt es pot denominar sortida d'energia.

Energia base:

Calor de combustió d'una matèria prima que no s'utilitza com a font d'energia en un sistema del producte, expressat en termes de poder calorífic superior o poder calorífic inferior.

Flux de producte:

Productes que entren o surten d'un sistema de producte cap un altre.

Emissions i abocaments:

Emissions a l'aire i abocaments a l'aigua i el terra.

Límit del sistema:

Conjunt de criteris que especificant quins dels processos unitaris són part del sistema de producte.

Factor de caracterització:

Factor que sorgeix d'un model de caracterització, que s'aplica per convertir el resultat del anàlisi de l'inventari del cicle de vida assignat a una unitat comú del indicador de categoria.

Categoria d'impacte:

Classe que representa assumptes ambientals d'interès a la qual es poden assignar els resultats de l'anàlisi de l'inventari del cicle de vida.

Indicador de categoria d'impacte:

Representació quantificable d'una categoria d'impacte.

Etiqueta ambiental; ecoetiqueta; declaració ambiental:

Manifestació que indica els aspectes d'un producte o servei.

una etiqueta o declaració ambiental pot prendre forma d'un enunciat, símbol o gràfic en un producte o en la etiqueta d'un envàs, en la documentació que acompanya el producte, en els bolletins tècnics i en els medis de publicitat o divulgació, entre d'altres.

[ISO 14040:2000]

Verificació de declaració ambiental:

Confirmació de la validesa d'una declaració mediambiental utilitzant criteris i procediments predeterminats específics, assegurant la fiabilitat de les dades.

Declaració mediambiental qualificada:

Declaració mediambiental que s'acompanya d'una explicació en la que es descriuen els límits de la declaració.

Auto declaració mediambiental; etiquetatge ecològic Tipo II:

Declaració ambiental efectuada per fabricants, importadors, distribuïdors, detallistes o qualsevol altre susceptible de beneficiar-se de dita declaració sense la certificació d'una tercera part independent.

Programa d'etiquetatge ecològic Tipo I:

Programa voluntari, multi criteri i desenvolupat per una tercera part, amb el que es concedeix una llicència que autoritza l'ús d'etiquetes ecològiques en productes i que indiquen que un producte, pertinent a una categoria de producte determinada, és preferible pel medi ambient en funció d'unes consideracions basades en el se cicle de vida.

Criteris ecològics del producte:

Requisits mediambientals que haurà de satisfer el producte per l'obtenció de la concessió de l'etiqueta ecològica.

Organisme de concessió de l'etiqueta ecològica:

Organisme de tercera part, i els seus representats, que dirigeixen el funcionament d'un programa d'etiquetatge ecològic Tipo I.

Tercera part:

Persona o organisme reconegut com independent de les parts implicades en el que es refereix a la matèria en qüestió.
Les parts implicades són generalment els interessos del subministrador("primera part") i el comprador("segona part).

Part interessada:

Qualsevol part afectada pel programa d'etiquetatge ecològic.

Titular de la llicència:

La part autoritzada per un organisme de concessió per utilitzar una etiqueta ecològica de Tipo I.

Llicència (per l'ús de l'etiqueta ecològica Tipus I):

Document preparat segons les disposicions d'un sistema de certificació amb el que l'organisme de concessió de l'etiqueta ecològica atribueix a un individu o organització els drets d'ús de l'etiqueta ecològica en els seus productes o serveis de conformitat amb les disposicions del programa d'etiquetatge mediambiental.

Declaració ambiental Tipus III:

Declaració ambiental que proporciona dades ambientals quantificades utilitzant paràmetres predeterminats i, quan faci falta, informació ambiental addicional.
Els paràmetres predeterminats es basa en la sèrie de normes ISO 14040, que esta formada per les normes ISO 14040 i ISO 14044
La informació ambiental addicional pot ser quantitativa o qualitativa.

Programa de declaració ambiental Tipus III:

Programa voluntari per desenvolupar i utilitzar declaracions ambientals Tipus III basat en un conjunt de regles operatives.

Administrador del programa:

Organisme o organismes que duen a terme un programa de declaracions ambientals Tipus III
L'administrador del programa pot ser una companyia o un grup de companyies, un sector industrial o una associació comercial, autoritzades o organismes públics, organismes científics independents o d'altres tipus.

Regles de categoria de producte; RCP:

Conjunt de regles específiques, requisits i guies pel desenvolupament de declaracions ambientals Tipus III per una o més categories de producte.

Revisió de les RCP:

Procés en el que un panell d'un tercer, verifica les regles de categories de producte.

Mòdul d'informació:

Recopilació de dades utilitzades com a base per la declaració ambiental Tipus III, que abasta un procés unitari o una combinació de processos unitaris que formen part del cicle de vida d'un producte.

Asseveració comparativa:

Declaració ambiental en relació amb la superioritat o la equivalència d'un producte respecte a un producte competidor que realitza la mateixa funció.

Abreviatures:

DAP Declaració ambiental de producte *Enviromental product declaration; EPD*

RCP Regles de categoria de producte *Product category rules; PCR*

ACV Anàlisi del cicle de vida *Life cycle assessment; LCA*

ICV Anàlisi de l'inventari del cicle de vida *Life cycle inventory analysis; LCI*

EICV Avaluació d'impacte del cicle de vida *Life cycle impact assassment; LCIA*

RSL Vida útil de referència *Reference service life*

ESL Vida útil estimada *Estimated service life*

EPBD Directiva d'eficiència energètica dels edificis *Energy performance of buildings directive*

GWP Potencial de escalfament global *Global warming potential*

ODP Potencial d'esgotament de la capa d'ozó estratosfèric *Depletion potential of the stratospheric ozone layer*

AP Potencial de acidificació del terra i els recursos d'aigua *Acidification potential of soil and water*

EP Potencial d'eutrofització *Eutrophication potential*

POCP Potencial de formació d'ozó troposfèric *Formation potential of tropospheric ozone*

ADP Potencial d'esgotament de recursos abiòtics *Abiotic depletion potential*

INTRODUCCIÓ:

Històricament en el sector de la construcció s'ha caracteritzat per la utilització de materials propers a l'emplaçament d'obra, bàsicament a causa del gran cost que suposava transportar els materials a llargues distàncies el qual suposava un increment de costos en ma d'obra i esforços que ho feia inviable a excepció de grans obres faraòniques . Per tant els costos energètics estaven acotats, els impactes ambientals eren reduïts o almenys fàcilment identificables. A més, existia una adaptació del disseny de l'edifici respecte a les condicions climàtiques locals, que repercutia en una major eficiència energètica i un major confort tèrmic per als ocupants.

Avui dia, a causa de la globalització i al nou ús de dissenys de construcció més estandarditzats i de materials amb un caràcter més global i menys específic com el formigó, l'alumini, el PVC, etc., han causat un increment dels seus costos energètics i mediambientals. Tanmateix, aquests materials que s'utilitzen en les obres modernes sovint es troben en altres regions i que per tant han de ser importats i requereixen un transport que agreuja els impactes al medi ambient. Per altre banda l'evolució tecnològica ha fet aparèixer noves tecnologies, metodologies i processos per a la construcció o conformació de materials, nous i antics.

L'Anàlisi de Cicle de Vida (ACV), és una de les metodologies més adequades per avaluar el cost mediambiental de qualsevol tipus de producte o servei i pot aplicar-se a qualsevol material físic o primari, solució constructiva, o fins i tot un edifici complet.

L'objectiu d'aquest Treball Final de Grau és realitzar una base de dades de materials físics o primaris de l'edificació, utilitzant la informació disponible a dia d'avui per a l'anàlisi de l'impacte mediambiental.

En aquest projecte s'expliquen els diferents abasts del cicle de vida, la utilització en documents de declaració ambiental i el programari i els mètodes de càlcul utilitzats per a la realització d'un cicle de vida.

Aquest treball s'ha realitzat en el Institut Tecnològic de la Construcció de Catalunya (ITeC), s'ha partit de la base de dades del BEDEC de la qual aquesta institució és propietària tenint en consideració els seus materials físics o primaris. La metodologia de càlcul i el criteri de presa de decisions finals han estat contrastada i validada per institucions públiques estatals.

L'objectiu final d'aquest treball és crear en les empreses del sector de la construcció la necessitat de complementar els resultats generalistes que obtenim, i així proporcionar dades comparables i més properes a productes comercials i per tant més exactes.

Les dades genèriques però, no desapareixeran mai, perquè són necessàries ja que sempre existiran partides d'obra genèriques on no hi ha fabricants que incorporin informació, per exemple un pilar de formigó armat.

1. EL CICLE DE VIDA (CV)

1.1 Definició

L'ACV solia rebre anteriorment altres noms, com eco-balanços, anàlisis del perfil ambiental i de recursos, anàlisi ambiental integral, perfils ambientals, entre d'altres, i es comparava amb altres eines tals com l'avaluació del risc ambiental i l'avaluació d'impacte ambiental.

LCA used to receive other names, such as eco-balances, analysis of environmental profile and resources, integrated environmental analysis, environmental profiles, among others, and are compared with other tools such as environmental risk assessment and the evaluation of environmental impact.

El que avui es coneix amb el nom de ACV va ser la denominació que per fi va acollir la comunitat internacional d'experts en el tema l'any 1991, acabant amb l'ambigüitat de termes relacionats deguda al fet que l'aplicació de la metodologia no només incorpora elements objectius sinó també elements subjectius.

What is known today with the name ACV was that it was hosted finally by the international community of experts of this subject in 1991, ending the ambiguity of terms related due to the fact that the application of methodology incorporates not only objective elements but also subjective elements.

Un anàlisis del cicle de vida, és una avaluació d'impactes ambientals associats a les diferents etapes de la vida d'un producte mitjançant la quantificació de l'ús dels recursos durant tota l'existència del mateix.

A life-cycle assessment is an evaluation of environmental impacts associated with the different stages of the life of a product through quantification of the use of resources throughout its existence.

Les declaracions ambientals en materials de construcció s'utilitzen per avaluar i comparar l'eficiència i el impacte dels mateixos. L'etiquetat resulta pràctic perquè es neutral i té un format estandarditzat sota les normatives ISO 14040 i ISO 14044 que facilita comparar diversos materials sota d'un mateix criteri de valoracions.

Statements in environmental building materials are used to evaluate and compare the efficiency and the impact thereof. The label is practical and neutral, and has a standardized format under the regulations ISO 14040 and ISO 14044 which facilitates the comparation of several materials under the same criteria evaluation.

S'ha de tenir en compte que els edificis produeixen impactes en el medi ambient al llarg de totes les etapes de la seva vida útil, començant per l'extracció de les matèries primeres i el seu transport, el consum d'energia necessari per a la fabricació dels materials constructius i el seu transport des de les plantes de producció fins a l'obra, els moviments de terra, consums energètics i residus que es produeixen durant la construcció dels edificis, el consum d'energia i l'aigua per satisfer les diferents demandes en l'ús dels edificis, el seu manteniment i finalment la seva demolició, així com la deposició final de tots els seus elements constructius al final de la seva vida útil. A més, totes aquestes etapes de la vida dels edificis estan fortament interrelacionades, de manera que els impactes en una de les etapes condicionen els impactes de les etapes següents.

We should consider that buildings produce impacts on the environment throughout all stages of its life, beginning with the extraction of raw materials and its transportation, energy consumption necessary for the manufacture of construction materials and its transport from the production plants to the worksite, earthmoving, energy consumption and waste produced during the construction of the buildings, energy consumption and water to meet different demands on the use of these buildings, its maintenance and finally its demolition as well as its final disposal of all building elements at the end of its useful life. Moreover, all the stages of the buildings' life are strongly interrelated, so the impact on one of these stages determine the impact of the following one.

L'interès que té aquesta eina de gestió mediambiental és que està orientada al producte, en contraposició a altres instruments, dirigits exclusivament al procés de fabricació o una fase concreta del producte. Això suposa un enfocament més ampli dels problemes mediambientals, que li imprimeix un caràcter preventiu en permetre corregir característiques d'impacte negatiu abans que el producte es trobi en fase de fabricació.

The interest of this environmental management is that it is focused on the product, in comparison to other instruments, directed exclusively to the manufacturing process or a specific phase of the product. This implies a broader approach to environmental problems, which prints a preventive features allowing the correction of negative impact before the product is in production stage.

Un altre dels punts forts del ACV és la capacitat d'aïllar els focus d'impacte, evitant així la imputació de càrregues mediambientals de forma repetitiva:

- Entre instal·lacions (per exemple entre la indústria que fabrica el producte i l'empresa encarregada del seu tractament o eliminació com a residu).

• Entre àrees geogràfiques (entre el lloc on s'extreu la matèria primera i el lloc on s'emmagatzema com a residu).

• Entre vectors mediambientals (la contaminació del sòl per un residu sòlid abandonat es transforma en contaminació atmosfèrica si es recull i es crema).

• En el temps (desfasament temporal produït per la transferència entre àrees geogràfiques o entre vectors susceptibles de rebre la contaminació).

Another of the strengths of LCA is the ability to isolate the impact focus, thus avoiding imputation of environmental burdens repetitively:

• Among facilities (between the manufacturer of the product and the company in charge of its treatment or its elimination as waste).

• Among geographical areas (the place where the raw material is extracted and where it is stored as waste).

• Among environmental vectors (soil contamination by abandoned solid waste will transform into air pollution if it is collected and burned).

• Over time (lag caused by the transfer between geographical areas or between vectors are eligible for pollution.

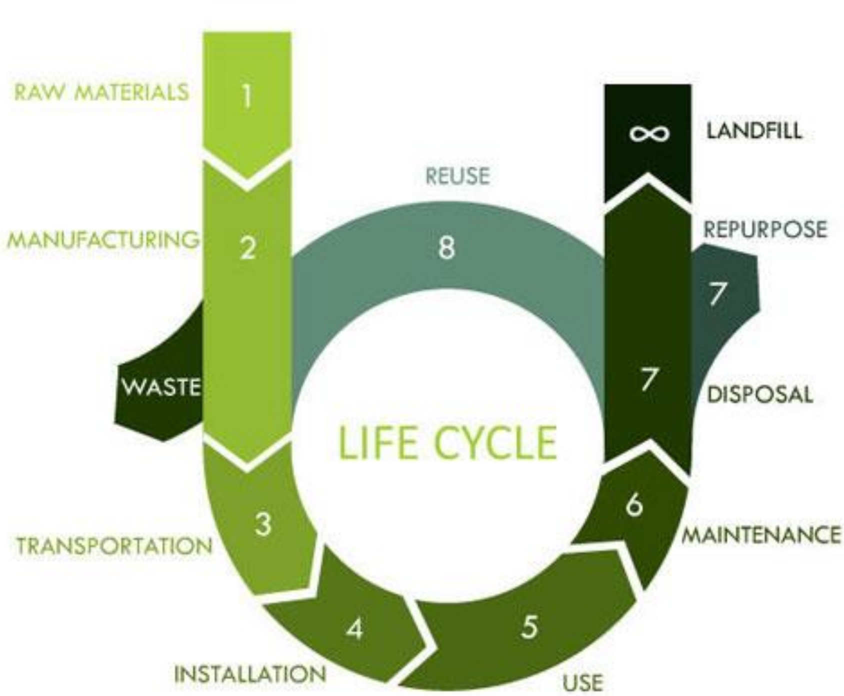


Figura 1: Representació del ACV

Font: https://sostenibledesign.wordpress.com/2013/04/19/analisis-del-ciclo-de-vida/

Per tant l'ACV permet determinar l'impacte de cascuna de les fases que intervenen en la creació. El fet d'identificar les parts, permet veure si un producte te més fases que un altre o menys, i permet saber si en realitat estem parlant de dos productes comparables. Per tant, cal determinar molt bé cadascun dels impactes que s'associa a les fases per tal d'estar comparant les parts i no el tot, és a dir, si ens posem a comparar els impactes que ens genera un producte, no podem mirar el valor final de l'impacte del mateix, compararem per exemple els impactes de la fase d'ús, o la fase de producció o l'impacte del transport etc. Això ens permet veure quina fase té més consum, quina és més ineficient, i per tant ens serveix per ser més eficaços en la realització del producte amb l'objectiu de poder contemplar totes les oportunitats de millora, tant actuals com a futures.

Therefore LCA determines the impact of each phase involved in the creation. The fact of identifying the parts, allows you to know if one product has more or less stages than the other, and to let you know if actually it is about two comparable products. Therefore it is necessary to determine each impact associated with the phases so as to be able to compare the parts and not the whole of it, that is, if we compare the impacts generated by a product, we will not be able to see the final value of its impact, for example comparing the impacts of phase I or the production phase or the impact of the transportation etc. This allows us to see which stage has more consumption, which is inefficient, and therefore helps us to be more effective in the performance of the product in order to be able to have all the opportunities for improvement, both current and future.

Per tot això, la reducció de l'impacte mediambiental dels edificis requereix l'aplicació de metodologies d'avaluació d'impacte adequades, de caràcter global, i que incloguin totes les etapes de la vida d'un edifici.

Els principals avantatges del ACV són:

- Instrument d'anticipació.
- Aporta informació al consumidor i a les parts implicades.
- És un instrument de gestió mediambiental complementari a altres eines com auditories mediambientals, avaluació d'impacte mediambiental, eco-etiquetat, etc.
- Defineix prioritats a l'hora d'invertir, en donar un pes estratificat en la incidència mediambiental.
- Permet als dissenyadors i productors així com a les empreses la planificació i presa de decisions fonamentades.
- Permet comparar productes i materials equivalents.

• Afavoreix l'ampliació dels criteris qualitat, impacte mediambiental, preu.

• Afavoreix el posicionament del producte al mercat sobre la base de la seva qualitat mediambiental, diferenciant-li de la competència, malgrat el fet que en les normes s'especifica que aquest tipus d'estudis no podran ser utilitzats com a comparacions comercials.

• Detecta les fallades i deficiències del producte i els punts forts del mateix baix criteris mediambientals.

• Identifica oportunitats de millora al llarg de tota la seva existència.

• Permet elaborar les mesures correctores pertinents en fase de disseny, avançant-se d'aquesta manera als futurs danys.

• És una eina científica clara, objectiva i transparent.

• És un anàlisi quantitatiu i qualitatiu.

Therefore, the reduction of the environmental impact of the buildings requires application of appropriate methodologies of global assessment of the impact which involves all stages of the building's life.

The main advantages of ACV are:

- Instrument advance.
- Provides information to consumers and stakeholders.
- It is an environmental management tool complementary to other tools such as environmental audits, environmental impact assessment, eco-labeling, etc.
- Set priorities when investing in a given weight in stratified environmental impact.
- Allows designers and producers as well as companies the planning and making of decisions.
- Allows you to compare products and materials equivalents.
- Promotes the expansion of quality standards, environmental impact, and price.
- Promotes product positioning in the market based on their environmental quality, differentiating it from the competition, despite the fact that the rules specify that this type of study can not be used as comparison shopping.
- Detect failures and shortcomings and strengths of the product under the same environmental criteria.
- Identify opportunities for improvement throughout their existence.
- Allows development of appropriate corrective measures in the design stage, thus anticipating future damage.

- It is a scientific tool clear, objective and transparent.
- It is a quantitative and qualitative analysis.

Tot i que existeixen estudis de ACV de productes industrials des de fa més de 40 anys, la seva aplicació al sector de l'edificació és relativament recent i requereix d'un esforç investigador per a la correcta adaptació de la metodologia que garanteixi el seu ús generalitzat per part d'agents del sector. En general, l'aplicació del ACV en l'edificació comporta una major complexitat pel que fa a altres sistemes més senzills, com per exemple, la fabricació de productes i components, que tenen lloc en entorns més controlats, en els quals es disposa de més informació.

Although the LCA studies of industrial products exist for over 40 years, its application in the construction sector is relatively new and requires a research effort for the correct adjustment methodology that guarantees its use widespread by industry players. In general, the application of LCA in building involves greater complexity with respect to other simpler systems, such as the manufacture of products and components, which take place in controlled environments, where more information is available.

Un dels grans inconvenients de l'ACV és que la seva metodologia requereix l'elaboració de bases de dades pròpies de cada país.

Altres limitacions significatives del ACV són:

- La naturalesa de les eleccions i hipòtesis que es fan en el ACV poden ser subjectives.
- Els models utilitzats per a l'anàlisi d'inventari o per avaluar impactes ambientals estan limitats per les seves hipòtesis i poden no estar disponibles per a tots els impactes potencials o aplicacions.
- Els resultats d'un ACV orientats a àmbits globals o regionals poden no ser apropiats per a aplicacions locals.
- La precisió dels estudis de ACV pot estar limitada per l'accessibilitat o disponibilitat de dades importants o per la qualitat dels mateixos.

Tots aquests aspectes s'han tingut en compte en el present projecte.

One of the major drawbacks is that the LCA methodology requires the development of its own databases of each country.

Other significant limitations of LCA are:

- The nature of elections and assumptions made in LCA may be subjective.
- The models used for the inventory analysis or to assess environmental impacts are limited by their assumptions and may not be available for all potential impacts or applications.
- The results of an LCA aimed at global and regional levels may not be appropriate for local applications.
- The accuracy of LCA studies may be limited by accessibility or availability of important data or their quality.

All these aspects have been taken into account in the present project

1.2 Normativa de l'ACV:

Les normatives que regulen l'ACV són una sèrie de normes ISO 14040 (Gestió ambiental – Anàlisi de Cicle de Vida):

- **ISO 14040**: Norma sobre Gestió Ambiental – Anàlisi de Cicle de Vida – Principis i estructura (1997, actualitzada en 2006). Ofereix una visió general de la pràctica, aplicacions i limitacions del ACV en relació a un ampli rang d'usuaris potencials, incloent aquells amb un coneixement limitat sobre el ACV.

- **ISO 14041**: Norma sobre Gestió Ambiental – Anàlisi de Cicle de Vida – Definició d'Objectius i Abast i Anàlisi d'Inventari (1998). Recull els requeriments i directrius a considerar en la preparació, aplicació o revisió crítica de l'anàlisi de l'inventari de cicle de vida (la fase del ACV referent a la recollida i quantificació dels consums i emissions rellevants que es produeixen en el cicle de vida d'un producte).

- **ISO 14042**: Norma sobre Gestió Ambiental – Anàlisi de Cicle de Vida – Avaluació de l'Impacte de Cicle de Vida (2000). Ofereix una guia sobre la fase del ACV consistent en l'avaluació d'impactes (que té com a objectiu l'avaluació dels impactes ambientals potencials i significatius a partir dels resultats de l'anàlisi d'inventari).

- **ISO 14043:** Norma sobre Gestió Ambiental – Anàlisi de Cicle de Vida – Interpretació del cicle de vida (2000). Ofereix una guia sobre la interpretació dels resultats del ACV en relació amb la definició d'objectius de l'estudi, incloent una revisió de l'abast del ACV, així com del tipus i qualitat de les dades utilitzades.

- **ISO/TR 14047**: Norma sobre Gestió Ambiental – Anàlisi de Cicle de Vida – Exemples d'aplicació de la ISO 14042 (2003).

- **ISO/TS 14048**: Norma sobre Gestió Ambiental – Anàlisi de Cicle de Vida – Normalització de dades i informació per a una avaluació de cicle de vida (2002).

- **ISO/TR 14049**: Norma de Gestió Ambiental – Anàlisi de Cicle de Vida – Exemples d'aplicació de la ISO 14041 (2000).

- **ISO 15804:** Norma de Gestió Ambiental - La norma UNE-EN 15804 estableix els criteris per desenvolupar les regles de categoria de producte (RCP) per tots els productes i serveis de construcció. Proporciona una estructura per garantir que totes les Declaracions ambientals de producte (DAP) dels productes de construcció, serveis de construcció i processos de construcció s'obtenen, verifiquen i presenten d'una forma harmonitzada (2012).

- **CEN/TR 15941:** Norma de Gestió Ambiental - Sostenibilitat en la construcció. Declaracions ambientals de producte. Metodologia per a la selecció i ús de dades genèriques (2011).

1.2 Regulations on LCA:

The regulations governing LCA is a series of ISO 14040 (Environmental Management - Life Cycle Analysis):

- ISO 14040: Standard on Environmental Management - Life Cycle Assessment - Principles and structure (1997, updated 2006). Provides an overview of the practical applications and limitations of LCA in relation to a wide range of potential users, including those with limited knowledge about LCA.
- ISO 14041: Standard on Environmental Management - Life Cycle Assessment - Objectives and Scope Definition and Inventory Analysis (1998). Collect requirements and guidelines to consider in the preparation, implementation or revision of critical analysis of the inventory life cycle (the phase of LCA regarding the collection and calculation of the relevant consumption and emissions occur in the product's life cycle).
- ISO 14042: Standard on Environmental Management - Life Cycle Assessment - Impact Assessment Life Cycle (2000). It provides guidance on the phase of the LCA consisting impact assessment (which aims at assessing the potential and significant environmental impacts from the results of the inventory analysis).

- ISO 14043: Standard on Environmental Management - Life Cycle Assessment - Life Cycle Interpretation (2000). It provides guidance on the interpretation of LCA results in relation with the definition of objectives of the study, including a review of the scope of the LCA, as well as the type and quality of the data used.
- ISO / TR 14047: Standard on Environmental Management - Life Cycle Assessment - Examples of application of ISO 14042 (2003).
- ISO / TS 14048: Standard on Environmental Management - Life cycle analysis - Standardization of data and information for life cycle assessment (2002).
- ISO / TR 14049: Standard for Environmental Management - Life Cycle Assessment - Examples of application of ISO 14041 (2000).
- ISO 15804: Environmental Management Standard - The UNE-EN 15804 establishes the criteria of developing product category rules (CPR) for all products and construction services. It provides a structure to ensure that all environmental product declarations (EPD) of building products, construction services and construction processes are obtained, verified and presented in a harmonized form (2012).

1.3 Fases de l'ACV:

Tal i com disposa la normativa UNE-ISO 14040:2006 els estudis de l'ACV consten de 4 fases principals:

D'acord amb la metodologia proposada per la normativa UNE-ISO 14040:2006 un projecte de ACV es divideix en quatre fases:

1. **La definició de l'objectiu i l'abast.**
2. **L'anàlisi de l'inventari. (ICV)**
3. **L'avaluació de l'impacte . (EICV)**
4. **La interpretació.**

1.3 LCA phases:

As the regulations UNE-ISO 14040: 2006 LCA the studies consist of four main phases:

According to the methodology proposed by the UNE-ISO 14040: 2006 the draft LCA is divided into four phases:

1. **The definition of the objective and scope.**
2. **Analysis of the inventory. (ICV)**
3. **The impact assessment. (EICV)**
4. **The interpretation.**

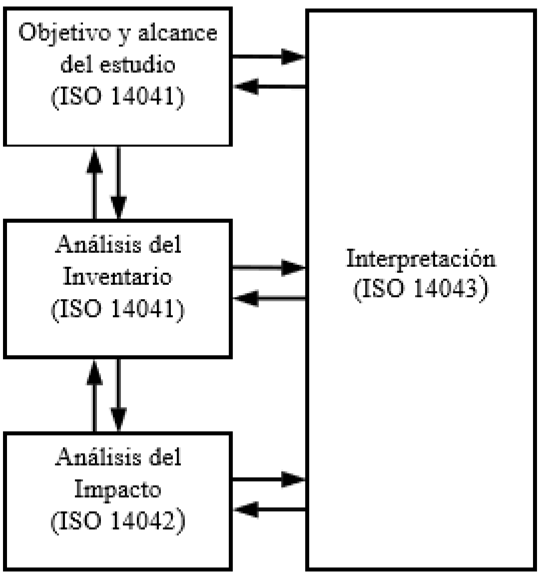


Figura 2: Fases del ACV

Font: ISO 14040

Tal com il·lustra la figura 2 aquestes quatre fases no són simplement seqüencials. El ACV és una tècnica iterativa que permet anar incrementant el nivell de detall en successives iteracions.

As the following figure 2 illustrates, the four phases are not simply sequential. The LCA is an iterative technique that allows to increase progressively the level of detail in successive iterations.

1. **Objectiu i abast de l'estudi:**

En aquesta fase s'ha de definir de forma clara i sense ambigüitats els objectius i l'abast del ACV sempre en funció del propòsit general de l'estudi. i si els resultats s'utilitzaran amb finalitats comparatives de diferents materials, components, productes i/o edificis, hauran d'utilitzar la mateixa unitat funcional, mètodes de càlcul, límits de sistema i avaluació d'impactes. La unitat funcional constitueix la unitat de referència per totes les entrades i sortides del sistema que s'obtindran en l'anàlisi de l'inventari del cicle de vida, ICV.

La definició de l'objectiu consisteix a assenyalar:

• L'aplicació del ACV.
• Les raons que han motivat la seva realització.
• El destinatari al que es comunicaran els resultats del mateix.

La definició de l'abast consisteix a identificar, de forma predictiva els següents elements:

• Funcions que ha de complir el producte objecte d'anàlisi.
• Unitat funcional, que subministra una referència per a totes les entrades i sortides del sistema i permet comparar els resultats del ACV.
• El sistema del producte a analitzar, referint-se amb això al principi de funcionament, metodologies i tecnologies aplicades.
• Els límits del sistema del producte.
• Regles d'assignació.
•Tipus d'impacte i metodologia d'avaluació d'impacte, així com la conseqüent interpretació a realitzar.
• Requisits de les dades.
• Hipòtesis realitzades per a la simplificació o funcionalitat.
• Limitacions a les quals es veu subjecte l'estudi.

1. Purpose and Scope of the study:

This phase should be defined clearly and unambiguously the objectives and scope of the LCA depending always on the purpose of the study. And if the results are used for comparative purposes in different materials, components, products and / or buildings they must use the same functional unit, calculation methods, limits and impact assessment system. The functional unit is the unit of reference for all inputs and outputs of the system obtained in the analysis of the inventory lifecycle, ICV.

The definition of the objective is to show:

- The application of LCA.
- The reasons for their realization.
- The recipient the results of it.

The definition of the scope is to identify predictively the following elements:

- Functions must meet the product analyzed.
- Functional unit, which provides a reference for all inputs and outputs of the system and compares the results of the LCA.
- The system to analyze the product, referring to the principle of this operation, methodologies and technologies.
- The system's limits of the product.
- Allocation Rules.
- Type of impact and methodology of impact assessment and the subsequent interpretation to be made.
- Requirements of the data.
- Assumptions made for simplification or functionality.
- Limitations subjected to study.

2. Anàlisi de l'inventari (ICV):

La segona fase, comporta l'anàlisi de l'inventari del cicle de vida, ICV. En aquesta etapa s'obtenen les dades i procediments de càlcul necessaris per a la quantificació de les entrades del sistema o sistemes, és una llista d'entrades i sortides en relació a l'estudi realitzat i definit per l'anterior fase. Es recullen de dades quantitatives i qualitatius sobre els quals es basarà la següent fase d'avaluació de l'impacte, es detallen i comptabilitzen totes les emissions que tenen un efecte rellevant en el procés, per això s'haurà de realitzar una recopilació d'informació, necessària per a la descripció de les matèries primeres, components i/o recursos energètics que s'involucrin en l'anàlisi de cicle de vida estudiat.

Perquè l'inventari sigui coherent amb l'objectiu de l'estudi han d'haver-se definit amb claredat els límits del sistema, els criteris de valoració de dades i l'entorn en el qual es duu a terme l'estudi; aquest últim determinarà els aspectes regionals a considerar (dades del país on es realitzi el anàlisi).Per a cada procés unitari, les entrades quantificades inclouen l'ús d'energia i matèries primeres, mentre que les sortides quantificades inclouen emissions a l'aire, aigua i sòl, subproductes i altres abocaments.

En cas que existeixin processos que donin lloc a més d'un producte, o els residus del producte siguin reciclats o reutilitzats per crear un nou producte, s'han d'aplicar criteris d'assignació que permetin un adequat repartiment dels impactes ambientals entre els diferents productes. Per exemple: en el procés de la creació d'un bolígraf de plàstic de PS (poliestirè) hi ha una pèrdua de material en forma d'encenalls. Per tal de ser més eficients, aquests encenalls es tornen a fondre per a reaprofitar-los juntament amb el material primari (boletes de PS). En aquest cas s'haurà d'aplicar un criteri per no duplicar els impactes. Com que als encenalls no se'ls computi cap impacte quan siguin reutilitzats com a matèria primera doncs ja se'ls a computat anteriorment.

2. Analysis of the inventory (ICV):

The second phase involves the analysis of the inventory lifecycle, ICV. At this stage the obtained data and calculation procedures are needed to quantify the inputs of the system or systems, it is a list of inputs and outputs in relation with the study and defined by the previous phase. Collected qualitative and quantitative data on which will base the next phase of impact assessment, detail and count all the emissions that will have a significant effect on the process, so it should be made a compilation of information necessary for the description of raw materials, components and / or energy resources involved in the analysis of life cycle study.

So that the inventory be consistent with the objective of the study you should define clearly the limits of the system, the valuation data and the environment in which it is carried out the study; the latter will determine the regional aspects to consider (the data of the country where the analysis was made) .For each process unit, quantified inputs include the use of energy and raw materials, while outputs include quantified emissions of air , water and soil, discharges and other waste products.
In case there are processes that give rise to more than one product or waste products recycled or reused to create a new product, allocation criteria should be applied to allow proper allocation of environmental impacts between different products. For example, in the creating process of a plastic pen PS (polystyrene) there is a loss of material in the form of chips. To be more efficient, these chips are re-melted for reuse along with the primary material (pellets PS). In this case a criterion to be applied not to duplicate the effects. As the chips were not computed any impact when they are reused as raw material, as they have been previously counted.

3. Anàlisi de l'impacte (EICV):

La tercera fase, és l'avaluació de l'impacte del cicle de vida, EICV. Consisteix en comparar les dades obtingudes en la fase anterior amb impactes ambientals específics per avaluar la seva importància i valorar aquests impactes. L'estructura d'aquesta fase és la següent:

3. Impact Analysis (EICV):

The third phase is assessing the impact of the life cycle, EICV. It consists of comparing the data obtained in the previous phase to evaluate specific environmental impacts and assess their significance impacts. The structure of this phase is:

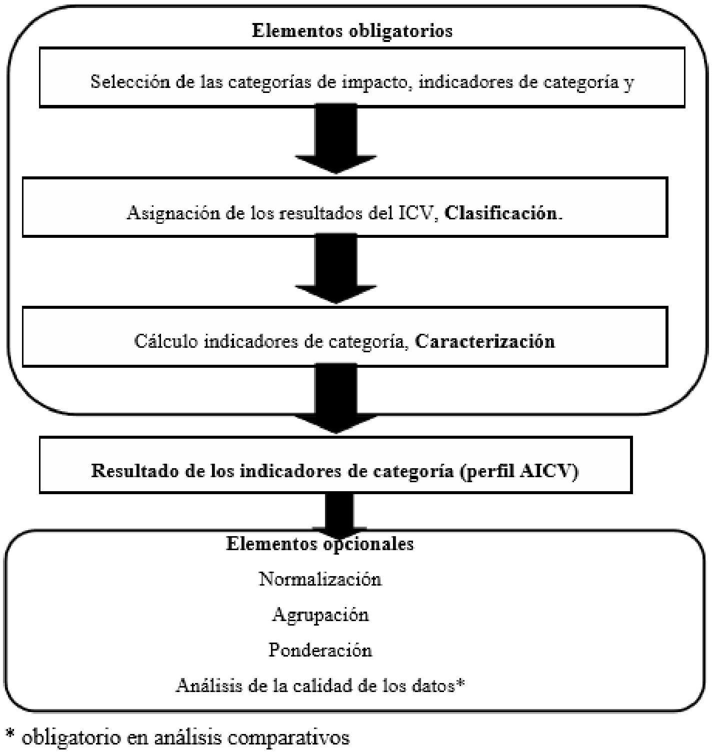


Figura 3: Elements obligatoris i opcionals del AICV

Font: ISO 14040

•Selecció de les categories d'impacte, indicadors de categoria i models.

•Classificació: assignació de les dades obtingudes en l'inventari a categories d'impacte.

• Caracterització: modelització mitjançant els factors de caracterització, de les dades de l'inventari dins de les categories d'impacte.

- Selection of impact categories, category indicators and models.
- Rating: mapping the data in the inventory impact categories.
- Characterization: modeling using characterization factors, the inventory data within impact categories.

Cada categoria d'impacte, precisa d'una representació quantitativa denominada indicador de la categoria, exemple. *Emissió de CO2 equivalent*. La suma de diferents intervencions ambientals per a una mateixa categoria es farà en la unitat de l'indicador de la categoria (figura 4). Mitjançant els factors de caracterització, també anomenats factors equivalents, les diferents intervencions ambientals, emissions de gasos per exemple, es converteixen a unitats de l'indicador. És necessari l'ús de models/mètodes de càlcul per obtenir aquests factors de caracterització. La aplicabilitat dels factors de caracterització dependrà de la precisió validesa i característiques dels models utilitzats (referenciats en Annexos). Cada model, dóna importància a uns indicadors diferents, depenent dels criteris de les diferents entitats científiques, per tant, s'hauran d'assignar els mètodes de càlcul pertinents segons els indicadors ambientals i la seva importància en els nostres càlculs.

Each impact category, eg. Acidification, global warming etc, requires a quantitative representation called indicator category, eg. Emission of CO2 equivalent. The amount of different interventions for the same environmental category will drive the indicator category (Figure 4). By characterization factors, also called similar factors, different interventions environmental gas emissions for example, are converted to units of the indicator. It is necessary to use models / methods of calculation for these factors characterization. The applicability of characterization factors depend on the accuracy and validity and characteristics of the models used (referenced in Appendices). Each model gives importance to different indicators, depending on the criteria of the various scientific organizations, therefore, should assign appropriate calculation methods depending on environmental indicators and their importance in our calculations.

4. Interpretació:

La quarta i última fase, és la interpretació de dades obtingudes de l'ICV i/o del EICV com a base per a les conclusions i presa de decisions d'acord amb l'objectiu i l'abast definits. La interpretació del cicle de vida intenta oferir una lectura comprensible, completa i coherent de la presentació dels resultats d'un ACV, d'acord amb l'objectiu i l'abast de l'estudi. Els resultats d'aquesta interpretació poden donar com a resultat conclusions i recomanacions per a la presa de decisions. Permet determinar en quina fase de l'ACV del producte es generen les principals cargues ambientals i per tant, en quins punts el sistema avaluat pot o s'ha de millorar.

La fase d'interpretació pot involucrar un procés iteratiu de revisió i d'actualització de l'abast d'un ACV.

4. Interpretation:

The fourth and final phase is the interpretation of data obtained from the ICV and / or EICV as a basis for the conclusions and decisions in accordance with the purpose and scope defined. The interpretation of the life cycle tries to offer a reading understandable, complete and consistent presentation of the results of LCA, according to the purpose and scope of the study. The results of this interpretation can give place to results the findings and recommendations for decision-making. To determine at what stage the ACV product generated major environmental charges and therefore evaluated the system in which points can or should be improved.

The interpretation phase may involve an iterative process of reviewing and updating the scope of an LCA

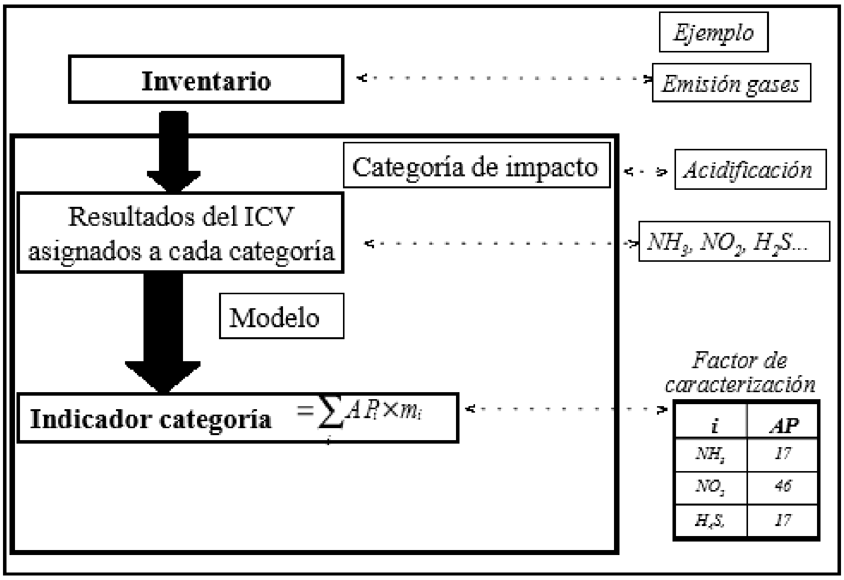


Figura 4: Esquema de la classificació i caracterització en la fase del AICV

Font: ISO 14040

1.4 Origen de l'ACV.

L'ACV no té un origen concret com a tal, però es poden situar en el temps una sèrie de estudis que a la llarga van evolucionar en la metodologia actual per l'ACV.

1.4 Origin of LCA.

LCA has no particular origin as such, but can be situated in time a number of studies that eventually evolved into the current methodology for LCA.

Anys 1960-1970 els inicis:

L'any 1963 Harold Smith presentar en la Conferència Mundial d'Energia de 1963 un dels primers estudis en els quals es van començar a tenir en compte els impactes ambientals dels productes en el qual informava sobre les quantitats d'energia necessària per a la fabricació de productes químics.

Years 1960-1970 beginnings:

In 1963 Harold Smith presented at the World Conference on Energy in 1963 one of the first studies when they began to consider the environmental impacts of products in which they reported of the amounts of energy needed to manufacture chemical productos.

Entre 1960 i 1970el Departament d'Energia d'Estats Units va encarregar un altre treball que pot catalogar-se de pioner i en el qual es va aplicar el concepte de cicle de vida, per determinar requeriments d'energia d'alguns processos i sistemes i l'anàlisi dels efectes ambientals per l'ocupació de l'energia.

Between 1960 and 1970el US Department of Energy commissioned another work which can be cataloged as pioneer and in which the concept of life cycle was applied, to determine energy requirements of certain processes and systems and the analysis of environmental effects by the use of energy.

Any 1969 Coca-cola:

1969 Coca-Cola

Figura 5: Evolució dels envasos de Coca Cola

Font: The Coca-Cola Company, Estats Units (US)/ http://www.coca-colacompany.com/

El 1969 Harry E. Teasley Jr. Director de la Divisió d'Envasos de Coca-cola Company, va protagonitzar probablement el que fins ara ha sigut el cas més famós dels ACV's. Coca-cola va encarregar un estudi de recerca al MRI (Midwest Research Institute) amb l'objectiu de determinar les quantitats d'energia, materials i impactes ambientals al llarg del cicle de vida dels seus envasos, des de l'extracció de matèries primeres fins a la seva deposició final, per escollir entre productes embotellats en plàstic i productes embotellats en vidre.

1969 E. Harry Teasley Jr. Director of the Division of packaging Coca-Cola Company, starred probably what has been so far the most famous case of LCA's. Coca-Cola commissioned a research study on MRI (Midwest Research Institute) in order to determine the amounts of energy, materials and environmental impacts throughout the lifecycle of their packaging, from the extraction of raw materials until its final disposal, to choose between products bottled in plastic and products bottled in glass.

La finalitat era saber si existia la possibilitat, i compensava a la companyia, d'emprar ampolles de plàstic, la qual cosa en aquesta època es considerava una idea absurda. A més aquest estudi analitzava si era convenient que la mateixa empresa fabriqués l'envàs, o externalitzar el procés, i quina gestió ambiental hauria de donar-se a l'envàs escollit, si reciclatge o deposició final.

The aim was to find out if there was a possibility, and if it compensated the company, to use plastic bottles, which at that time was considered a crazy idea. Furthermore, this study analyzed whether if it was appropriate that the company manufactured the packaging or outsource the process, and what environmental management should be given on the package chosen, whether recycling or final disposal.

Contrari al que tots s'esperaven, els envasos plàstics eren la millor opció. Gràcies a això, es va canviar la percepció negativa del públic i la indústria respecte als plàstics. El departament de màrqueting va obrir una nova línia de producte, les ampolles de vidre es vendrien més cares perquè conservaven millor el gas mentre que les de plàstic començarien a formar part del producte més estandarditzat.

Contrary to what everyone expected, the plastic containers were the best option. Thanks to this, it changed the public and industry's negative perception regarding plastics. The marketing department opened a new line of products, glass bottles would be sold more expensive because it kept better gas whereas the plastic became part of the standardized product.

A partir d'aquest estudi a Estats Units es va anomenar REPA (Resources and Environmental Profile Analisis) a la metodologia per quantificar els recursos i les descàrregues ambientals dels productes, al mateix temps que es buscava perfeccionar cada vegada més aquesta metodologia en aquest país.

From then onwards this study in the United States is called Repair (Resources and Environmental Profile Analysis) methodology to quantify the environmental resources and downloads of products, while it sought to improve this methodology in this country.

Context històric que va desencadenar l’interès pel ACV.

A l'octubre de 1973, la guerra de Yom Kippur va enfrontar militarment a Israel contra Síria i Egipte, aquest succés va fer que l’Opep (Organització de Països Exportadors de Petroli) embargués el subministrament de petroli als països d'Europa i Estats Units, com a resposta a la decisió que va prendre aquest últim de recolzar militarment a Israel durant la guerra. Això va portar com a conseqüència un augment important en els preus mundials del petroli. La crisi va cridar l'atenció dels països desenvolupats, principalment d'Estats Units, sobre la dependència marcada en els combustibles fòssils pel creixement industrial i l'economia del món, la qual cosa va portar al debat públic la necessitat de prendre mesures per a l'estalvi de l'energia i un interès major sobre la cerca d'energies alternatives (en aquell moment es parlava de la solar i eòlica, especialment) i sobre la urgència de desenvolupar productes ambientalment responsables.

Historical context that triggered the interest in ACV.

In October 1973 the Yom Kippur war Israel confronted militarily against Syria and Egypt, this event made the OPEC (OPEC) impounded oil supplies to European countries and the United States, in response to the decision of the latter to support Israel militarily during the war. Consequently this brought a significant global increasement in the prices of oil. The crisis struck the developed countries, mainly the United States, outstanding dependence on fossil fuel in industrial growth and the world economy, which led to public debate the need to take measures on saving energy and a greater interest on the research for alternative energies (at that time there was talk of solar and wind energy, in particular) and the urgent need to develop environmentally responsible products.

Al 1971 es va dur a terme un segon REPA per MRI per Mobil Chemical Company, en el qual es van analitzar safates d'escuma de poliestirè i safates de cartró que s'utilitzaven per empaquetar la carn dels supermercats. Aquest estudi va sorgir perquè els fabricants de safates de cartró els deien als seus clients que les safates plàstiques eren un problema ambiental seriós. Per a sorpresa de tots, les safates plàstiques van resultar ambientalment millors ja que la safata plàstica pesava molt poc i emprava menys material, comparada amb la safata de cartró, que era més pesada.

In 1971 a second review was carried out by Mobil Chemical Company MRI, in which were analyzed the Styrofoam and cardboard trays used for packaging meat in the supermarkets. This study turned up due to comments of the clients to the manufacturer that the plastic trays were a serious environmental problem. To everybody's surprise, plastic trays were environmentally better because they weighed very little and needed less material compared to cardboard trays, which were heavier.

En 1972, l'USEPA (O.S. Environmental Protection Agency) va encarregar al MRI la realització d'estudis per avaluar les implicacions ambientals d'envasos de begudes gasoses i decidir si era convenient promocionar l'ús d'ampolles i llaunes retornables en comptes de les no retornables. Paral·lelament, en el Regne Unit, Ian Boustead del Departament de Ciència dels Materials de l'Open University, va adaptar la metodologia utilitzada a la Universitat d'Illinois sobre el càlcul d'envasos de begudes per calcular l'ús total d'energia de diferents classes d'envasos per a llet, entre elles, vidre, acer, alumini i plàstic.

In 1972, the USEPA (US Environmental Protection Agency) commissioned MRI studies to assess the environmental implications of soft drinks containers and to decide whether if it was appropriate to promote the use of returnable bottles and cans instead of non-returnable. Meanwhile, in the UK, Ian Boustead Department of Materials Science at the Open University, adapted the methodology used at the University of Illinois on the calculation of beverage containers to calculate the total use of power of different classes of packaging milk, including glass, steel, aluminum and plastic.

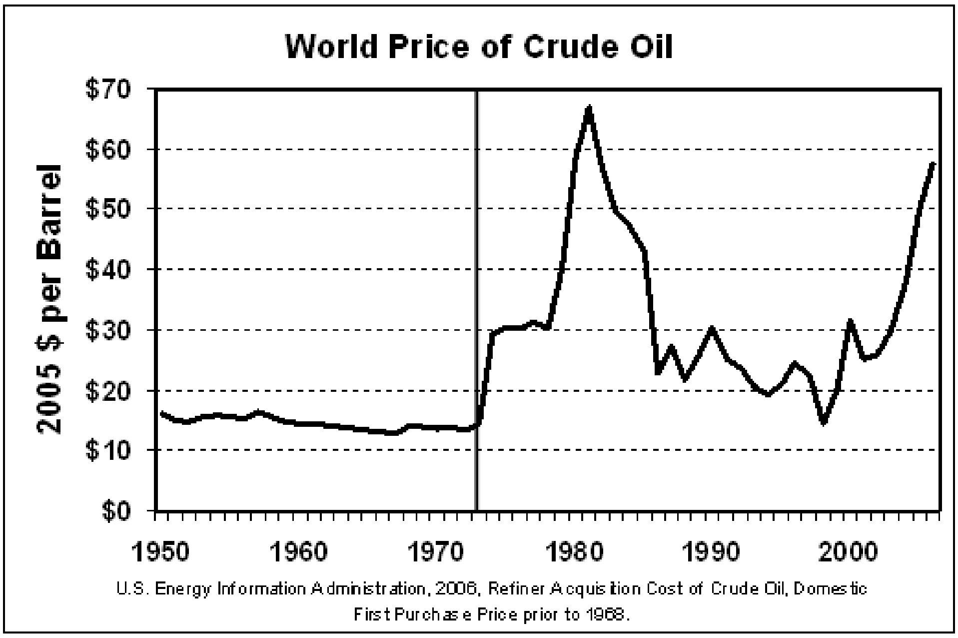


Figura 6: Evolució del preu del cru

Font: http://www.esd.ornl.gov/eess/energy_analysis/oil_independence.shtml

Any 1975 fundació de Franklin Associates:

Al 1975, William Franklin, un dels experts en REPA del MRI (Midwest Research Institute), va fundar juntament amb Marge Franklin una de les empreses capdavanteres en ACV d'Estats Units, la signa Franklin Associates, la qual va dur a terme més de 60 estudis, principalment per a companyies del sector privat.

En 1976 l'Agència Federal d'Energia d'Estats Units, que després es convertiria en el Departament d'Energia, va posar a la disposició del públic bases de dades i la metodologia REPA derivada d'estudis que van dur a terme Franklin Associates i research triangle institute sobre envasos de begudes.

1975 founding of Franklin Associates:

In 1975, William Franklin, an expert review of the MRI (Midwest Research Institute), founded together with Marge Franklin one of the leading companies in LCA in the United States, signed Franklin Associates, which conducted more than 60 studies, mainly for companies in the private sector.

In 1976 the Federal Energy Agency of the United States, which later became the Department of Energy, made available to the public database and methodology derived review of studies conducted by Franklin Associates and Research Triangle Institute on beverage containers.

Figura 7: Logo Franklin Associates

Font: Franklin Associates, Estats Units (US) / http://www.fal.com/

Any 1975-1988 Pèrdua d'interès en els ACV:

Entre els anys 1975 i 1988, a Estats Units va començar a disminuir l'interès pel ACV perquè es pensava que després d'haver passat la crisi del petroli, ja s'havien fet molts estudis REPA i avanços en solucions als problemes ambientals, principalment sobre residus sòlids i consum d'energia, un reflex d'això va ser que l'Agència de Protecció Ambiental d'Estats va decidir que l'ocupació del ACV no era pràctic. Tot i així, es continuaven fent estudis per part de les empreses de caràcter confidencial.

Year 1975-1988 Loss of interest in ACV:

Between 1975 and 1988 the United States began to lose interest in LCA because they thought that after the last oil crisis many studies had been done and review progress in solutions to environmental problems, mainly solid waste and energy consumption, this reflection of the Environmental Protection Agency decided that the US occupation of ACV was not practical. However, they continued doing studies confidentially for the companies.

Al 1988 va tornar a renéixer l'interès per l'ACV a Estats Units, amb l'ocasió del que alguns van denominar "la crisi dels residus sòlids", que va començar a causa de que un munt d'escombraries estava surant en el mar i cap port volia encarregar-se de la seva disposició final. Aquest fet juntament amb la pressió, que per a aquesta mateixa època estaven sentint les empreses multinacionals a les seves seus d'Europa (pel Moviment Verd, que tenia molt d'èxit llavors), van fer ressorgir la preocupació per la gestió dels residus sòlids.

In 1988 the interest in ACV reborned in the United States, in this occasion what some call "the crisis of solid waste," It all started because a lot of garbage was floating in the sea and no port wanted to take charge of their final disposal. This fact along with the pressure, which at this time were feeling multinational companies at their headquarters in Europe (by Green Movement, which wasvery successful at that moment), made resurgence concern for solid waste management.

Any 1990 El naixement del LCA o ACV i el cas dels bolquers:

Al 1990 es va desenvolupar el primer taller de la SETAC (Society of Environmental Toxicology and Chemistry) per discutir la metodologia i utilitat dels REPA. En aquesta trobada es va l'adoptar el terme actual “Life Cycle Assessament” (LCA) o “Anàlisi del cicle de vida” (ACV).

1990 Birth of LCA and LCA or the case of diapers:

In 1990 the first workshop SETAC (Society of Environmental Toxicology and Chemistry)was developed to discuss the methodology and usefulness of the review. At this meeting it adopted the current term "Life Cycle Assessament" (LCA) or "life cycle analysis" (LCA).

Al 1990, un treball de Franklin Associates va generar gran controvèrsia entre el públic nord-americà perquè va ser el que primer va usar el concepte de cicle de vida per determinar els impactes ambientals adversos i benèfics dels productes, i també perquè indagava si ambientalment eren millors els bolquers de tela reutilitzables o els bolquers d'un sol ús.

In 1990, Franklin Associates work generated many controversy among the American public because it was the first to use the concept of life cycle to determine the beneficial and adverse environmental impacts of the products, and also because they were investigating whether it were environmentally better reusable cloth diapers or disposable diapers.

Contrari al que tothom pensava, els bolquers d'un sol ús tenien 90 vegades més residus sòlids, però únicament el 2% de la totalitat dels residus municipals, mentre que els bolquers reutilitzables ocasionaven deu vegades més contaminació de les aigües (pels detergents, principalment) i consumien tres vegades més energia.

Contrary to what everyone thought, disposable diapers had 90 times more solid waste, but only 2% of all municipal waste, while reusable diapers caused ten times more water pollution (by detergents, mainly) and consume three times more energy.

Figura 8: logo SETAC

Font: Society of Environmental Toxicology and Chemistry, Estats Units (US) / http://www.setac.org.

Any 1992 Creació de SPOLD, Europa s'uneix a l'ACV:

En 1992, Franklin Associates va publicar un article on es presentava completa per primera vegada la metodologia de l'ACV. A més, aquest mateix any a Europa, es crea SPOLD (Society for the Promotion Of LCA Development), una associació de 20 grans companyies europees amb l'objectiu de promoure el desenvolupament i l'aplicació del ACV.

1992 Creation SPOLD Europe joins LCA:

In 1992, Franklin Associates published an article which appeared for the first time the complete LCA methodology. This year in Europe creates SPOLD (Society for the Promotion of LCA Development), an association of 20 major European companies with the aim of promoting the development and application of LCA.

Any 1997 Estandardització, ISO 14040:

El 16 de juny de 1997 es va publicar per primera vegada la primera norma internacional de la sèrie ISO 14040 sobre l'anàlisi del cicle de vida, titulada "Environmental Management – Life Cycle Assessament – Principles and Framework". El codi de pràctiques que SETAC va publicar en 1993 va ser un impuls important en el desenvolupament d'aquest estàndard mundial així com la contribució de diversos tallers internacionals a Europa i Estats Units promoguts per SETAC.

1997 Standardization, ISO 14040:

On 16 June 1997 it was published for the first time the first international standard ISO 14040 series on life-cycle assessment, entitled "Environmental Management - Life Cycle Assessament - Principles and Framework." The code of practices SETAC published in

1993 was a major boost to the development of this global standard as well as the contribution of various international workshops in Europe and the United States sponsored by SETAC.

Any 1999 Aparició de les normatives ISO 14020 i ISO 14021 i amb elles les etiquetes ecològiques:

En 1999, es van implantar noves normatives de la sèrie ISO 14040, com són les normes ISO 14024, que fa referència a etiquetatge ecològic i declaracions ambientals (Tipus I), i ISO 14021, referent a etiquetatge ecològic i declaracions ambientals (Tipus II).

In 1999, new regulations were introduced ISO 14040 series, such as ISO 14024, which refers to eco-labeling and environmental statements (Type I) and ISO 14021 concerning eco-labeling and environmental declarations (Type II).

Any 2000 - nous programaris, noves institucions i assentament de les bases de l'actualitat:

En el 2000 es va incrementar l'elaboració d'estudis de ACV a tot el món, amb èmfasis en el tema dels combustibles fòssils, biocombustibles, energia nuclear i energies renovables per produir electricitat, i perfeccionament de la metodologia per fer anàlisi de cicle de vida. A conseqüència, entre els anys 1999 i 2003 es va disparar la venda de llicències de programari.

2000 - New software, new institutions and setting the basis for today:

In 2000 it increased the development of LCA studies worldwide, with emphasis on the issue of fossil fuels, biofuels, nuclear power and renewable energy to produce electricity, and improvement of the methodology to cycle analysis life. As a result, between 1999 and 2003 soared selling software licenses.

Aquest mateix any 2000, a Suïssa, es va fundar el Centre Suís per a Inventaris de Cicle de Vida (The Swiss Center for Life Cycle Inventories), conformat per institucions i departaments dels instituts federals suïssos, incloent Agroscope (centre suís d'excel·lència per a la recerca agrícola), el PSI (Paul Scherrer Institute), la EPFL (École Polythechnique Fédérale de Lausanne), el ETH de Zuric (Eidgenössische Technische Hochschule, institut federal suís de tecnologia) i la EMPA (Swiss Federal Laboratories for Materials Science and Technology).

That same year 2000, in Switzerland, it was founded the Swiss Centre for Life Cycle Inventories (The Swiss Center for Life Cycle Inventories) upon the institutions and departments of the Swiss federal institutes, including Agroscope (Swiss center of excellence excellence for agricultural research), the PSI (Paul Scherrer Institute), the EPFL (Ecole Polythechnique Fédérale de Lausanne), the ETH Zurich (Eidgenössische Technische Hochschule, Swiss Federal Institute of Technology) and EMPA (Swiss Federal Laboratories for Materials Science and Technology).

Aquest centre, en 2003, va desenvolupar la base europea Ecoinvent, actualment una de les més reconegudes i usades per la comunitat internacional pels estudis de cicle de vida, especialment en la fase d'inventari.

This center, in 2003, was developed in the European base Ecoinvent, currently one of the most recognized and used by the international community for studies of the life cycle, especially in the phase of inventory.

Figura 9: logo ecoinvent

Font: Ecoinvent centre, Suïssa (CH) / http://www.ecoinvent.ch/

Any 2006 - Naixement de la sèrie de normes ISO 14040, estandardització definitiva:

En el 2006 la sèrie de normes ISO 14040 augmenta amb la incorporació de les noves normes ISO 14025, fa referència a etiquetatge ecològic i declaracions ambientals (Tipus III), i ISO 14044, que detalla l'anàlisi del cicle de vida, els seus requisits i directrius.

L'edició de la norma ISO 15804 és una de les més actuals, 2012, i és una modificació de la norma ISO 14025 per emmotllar-la als productes de la construcció.

2006 - Birth of the ISO 14040 series of standards, standardization short:

In 2006 the ISO 14040 series of standards increases with the addition of the new ISO 14025 refers to eco-labeling and environmental declarations (type III), and ISO 14044, which details the life-cycle assessment, its requirements and guidelines.

The publication of ISO 15804 is one of the latest, 2012 and is a modification of ISO 14025 to conform to the construction products.

Any 2011 – Normes PAS 2050:2011 y PAS 2060, la petjada de carboni:

Cada cop més el canvi climàtic és més important per part de les nacions, governs i empreses, per aquest motiu British Standards Institution (BSI) ha desenvolupat dues normes que en l'actualitat són referència, i les més utilitzades per al càlcul de la Petjada de Carboni de productes (PAS 2050) i per a la demostració de la neutralitat de carboni (PAS 2060).

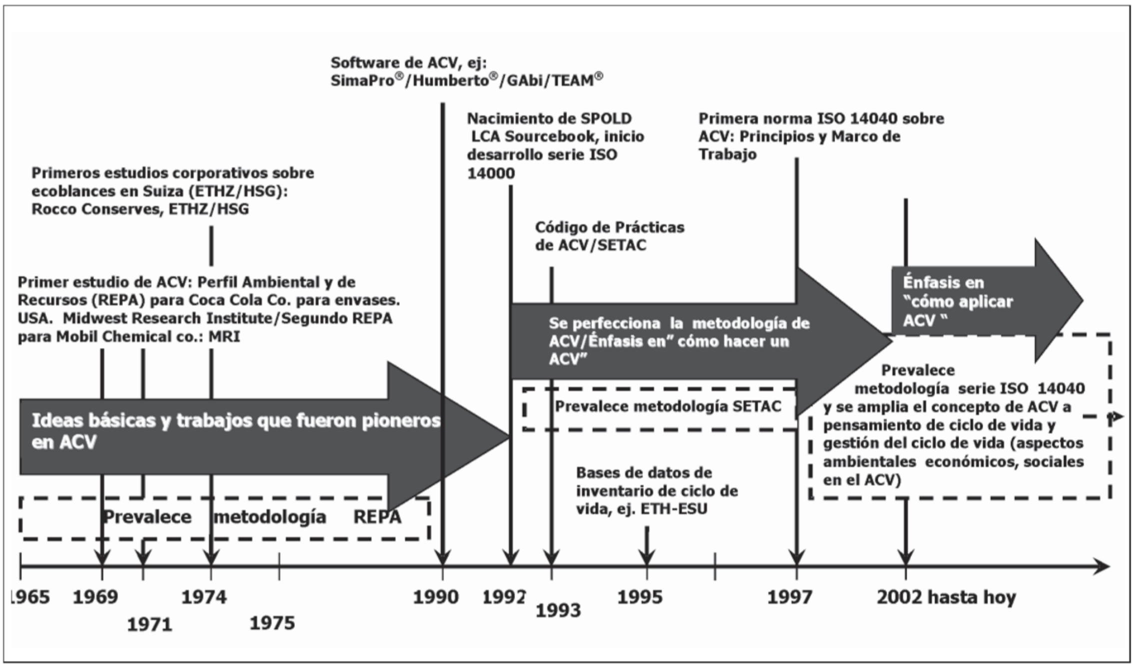
2011 - Standards PAS 2050: 2011 and PAS 2060, carbon footprint:

Increasingly climate change is the most important part of the nations, governments and businesses, that is why British Standards Institution (BSI) has developed two standards that are current references and the most used for calculating Footprint carbon products (PAS 2050) and the demonstration of carbon neutrality (PAS 2060).

bsi.

Figura 10:

Font: British Standards Institution, Regne Unit (UK) / http://www.bsigroup.com/



Fuente: Tomado y modificado de Siegenthaler, 2008.

Figura 1. Evolución histórica y tendencias del análisis de ciclo de vida (ACV).

Figura 11: Línia temporal de la historia del ACV

Font: Revista escuela Colombiana de ingenieria nº72 Octubre – Diciembre 2008

1.5 Sistemes d'etiquetatge:

1.5.1 Eines de comunicació ambiental:

Les eines de comunicació ambiental informen als consumidors sobre el caràcter ambiental dels productes, per a aquesta funció, el mitjà més emprat és l'eco-etiquetat, en qualsevol de les seves versions.

Adherides o impreses en els embalatges o fins i tot en els propis productes, intenten encoratjar la demanda de béns més respectuosos amb el medi ambient i estimular així el potencial per a una millora ambiental contínua i sostenible.

Actualment existeix una amplia varietat de sistemes d'informació i comunicació ambiental de producte, aquests es poden classificar en dos grups ben diferenciats: voluntaris o obligatoris; auto-certificats o certificats per un tercer; de contingut negatiu, positiu o neutre; etc.

Una classificació dels sistemes existents de comunicació és la que inclou no només sistemes relacionats amb el producte, sinó també per a les corporacions. A continuació, es detalla la classificació:

1. **Sistemes obligatoris / Etiquetes obligatòries**:
   Els imposa la legislació i tenen com a finalitat garantir la seguretat, la salut pública y la protecció dels consumidors, per exemple:
   - Declaració de la composició dels productes.
   - Informació sobre riscos per a la salut o el medi ambient durant l'ús o gestió del producte en la seva fi de vida.
   - Etiquetatge de producte que mitjançant símbols informa sobre les seves característiques específiques (per exemple, perillositat).
   - Certificació de conformitat del compliment de determinats requisits (per exemple, marcatge CE)

Per exemple:

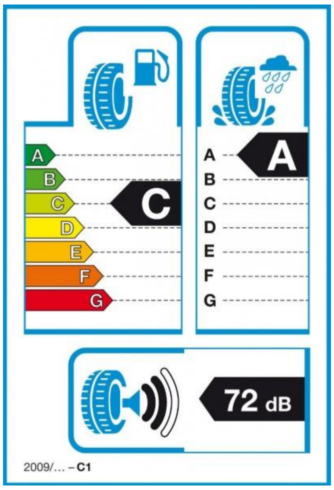


Figura: 12
Font: http://www.auto10.com/reportajes/la-nueva-etiqueta-para-los-neumaticos-como-elegir-bien-tus-proximas-ruedas/2391 a data: 23/05/2015

Per a la elaboració del projecte ens centrem en les ecoetiquetes o sistemes voluntaris, i en concret les del Tipus III (declaracions ambientals de producte), eina que pretén ser un estàndard de comparació regulats per la norma ISO 14025.

2. **Sistemes voluntaris**: en aquest cas, són els fabricants els que decideixen si volen o no desenvolupar-los. Des de la dècada dels 80, aquests sistemes es van expandir com a alternativa als de comandament i control. ISO els classifica en tres grans grups:

   - **Etiquetes Tipus I**, etiqueta ecològica. [**UNE-EN ISO 14024]**
   - **Etiquetes Tipus II**, auto declaracions mediambientals. [**UNE-EN ISO 14021]**
   - **Etiquetes Tipus III**, declaracions ambientals. [**UNE-EN ISO 14025]**

   La norma **UNE-EN ISO 15804** és la normativa específica dels productes de la construcció i és la que s'ha estudiat en aquest projecte.

L'etiquetatge voluntari és un distintiu que s'atorga a determinats productes, que seguint una sèrie de criteris ecològics, es considera que tenen menor impacte mediambiental que altres productes de la mateixa categoria.

Els orígens de les eco-etiquetes es poden trobar en la creixent consciència global de protegir el medi ambient per part dels governs, les empreses i el públic en general. Inicialment i sobretot als països desenvolupats, algunes empreses van reconèixer que aquesta consciència global podia generar un avantatge competitiu per a certs productes. Llavors s'incloïen etiquetes amb expressions com a reciclable, baixa energia i contingut reciclat, entre moltes altres.

L'objectiu global de les etiquetes i declaracions ambientals és encoratjar la demanda i el subministrament d'aquells productes i serveis que afecten menys al medi ambient, i estimular així el potencial per a la millora ambiental contínua impulsada pel mercat, per mitjà de la comunicació d'informació verificable, precisa i no enganyosa sobre els aspectes ambientals dels productes i serveis.

Els principis generals de les eco-etiquetes i declaracions ambientals són els següents:

- Les etiquetes i declaracions ambientals han de ser precises, verificables, pertinents i no enganyoses.

• Els procediments i requisits de les etiquetes i declaracions ambientals no s'han de preparar, adoptar o aplicar amb la intenció de crear obstacles innecessaris en el comerç internacional.

• Les etiquetes i declaracions ambientals han de basar-se en una metodologia científica prou exhaustiva i comprensiva per recolzar l'afirmació i produir resultats exactes i reproduïbles.

• La informació relativa al procediment, a la metodologia i a qualsevol criteri utilitzat per recolzar les etiquetes i declaracions ambientals, ha d'estar disponible i ser subministrada a totes les parts interessades.

• El desenvolupament d'etiquetes i declaracions ambientals ha de tenir en compte tots els aspectes pertinents del cicle de vida del producte, encara que això no significa necessàriament que s'ha de realitzar una anàlisi del cicle de vida.

• Les etiquetes i declaracions ambientals no han d'obstaculitzar les innovacions que sustenten l'acompliment ambiental o tenen el potencial per millorar-ho.

• Tot requisit administratiu o demanda d'informació pel que fa a les etiquetes i declaracions ambientals ha de limitar-se a aquells necessaris per establir la conformitat amb els criteris i les normes aplicables.

• És convenient que el procés de desenvolupament etiquetes i declaracions ambientals inclogui una consulta oberta i participativa amb les parts interessades.

• La part que fa una etiqueta o declaració ambiental ha de posar a la disposició dels compradors actuals i els compradors potencials, la informació sobre els aspectes ambientals de productes i serveis relacionats amb l'etiqueta o declaració ambiental.

1.5.2 Eco-etiquetes tipus I o etiqueta ecològica:

Les eco-etiquetes tipus I solen abraçar diferents tipus de productes o serveis i indiquen que un producte és ambientalment preferible en funció d'una sèrie de consideracions basades en el seu cicle de vida i per tant ajuden a contribuir una reducció dels impactes mediambientals associats als productes.

Estan orientats a productes de gran consum destinats al consumidor final, per això ofereixen al consumidor informació concisa i qualitativa que li ajuda a prendre decisions ràpides de compra.

A diferencia de les del tipus II, aquestes son atorgades per una tercera part independent, la qual sol ser una administració pública ambiental.

Tanmateix el temps de validesa ha de fixar-se per a un període predefinit ja que han de tenir en compte factors com les noves tecnologies, nous productes, nova informació mediambiental i canvis en el mercat.

Aquestes eco-etiquetes estan estandarditzades per la norma ISO 14024:2001. En el desenvolupament dels criteris d'aquest tipus de eco-etiqueta s'utilitza la metodologia del ACV.

Un programa d'etiquetatge ecològic Tipus I hauria de ser capaç de demostrar la seva transparència al llarg de totes les seves etapes de desenvolupament i aplicació. La transparència suposa que la informació ha d'estar disponible a les parts interessades per a la seva revisió i per efectuar comentaris quan sigui apropiat. Ha de permetre's un termini de temps adequat per a la presentació dels comentaris oportuns. És convenient que aquesta informació inclogui:

- Selecció de les categories de producte.
- Selecció i desenvolupament dels criteris ecològics del producte.
- Les característiques funcionals del producte.
- Els mètodes d'assaig i verificació.
- Els procediments de certificació i concessió.
- El termini per a la revisió dels criteris.
- El termini de validesa dels criteris.
- L'evidència de naturalesa no confidencial en la qual se sustenta la concessió.

• Les fonts de finançament del programa.

• El procés de verificació de la conformitat.

Exemples:

Figura 13: Garantia de qualitat ambiental
Font: Generalitat de Catalunya / http://mediambient.gencat.cat/

Figura 14: Etiqueta ecològica europea
Font: Ministerio de agrigultura, alimentación y medioambiente
http://www.magrama.gob.es/

Figura 15: Etiqueta d'Aenor
Font: Aenor,
http://www.aenor.es/

1.5.3 Eco-etiquetes tipus II o Autodeclaracions ambientals:

Les eco-etiquetes del tipus II son declaracions fetes pel propi fabricant, importador o venedor del producte sense necessitat d'una certificació per tercera part. A més, el component de màrqueting està molt més present en aquest tipus d'etiquetatge, corrent el risc d'exagerar els beneficis ambientals de la utilització del producte.

Poden ser afirmacions, símbols o gràfics que apareixen en el propi producte o en el seu envàs, catàleg, publicitat, etc. Normalment només consideren una etapa del cicle de vida i un únic aspecte ambiental, un exemple d'auto-declaració és el denominat , les tres fletxes que tots relacionem amb el reciclatge. Aquesta etiqueta pot tenir dos significats: que un envàs és de material reciclat i també que un producte és reciclable. En ocasions veurem un percentatge dins d'aquest triangle, aquesta xifra indica la proporció de material reciclat que conté.
La tasca del consumidor en la seva elecció diària de productes ecològics es complica davant la gran varietat de sistemes d'etiquetatges existents en l'actualitat.
Per això és fonamental aprendre a reconèixer les eco-etiquetes concedides per organismes oficials i organitzacions fiables (Tipus I) que, per tant, ofereixen major credibilitat que les que es poden atorgar les pròpies marques.

El consumidor ha de fugir de proclames que no comptin amb un suport verificable i saber identificar distintius que imiten els oficials pretenent compartir les seves bondats a més del disseny.

Els següents requisits establerts en la norma UNE-EN ISO 14021 són aplicables a totes les Auto-declaracions mediambientals:

- Quan la norma UNE-EN ISO 14021 presenti requisits més específics que els contemplats en la norma UNE-EN ISO 14020, seran aquests els que s'hauran de tenir en compte.
- No han de realitzar-se declaracions mediambientals imprecises o que de manera general indueixin a pensar que un producte és mediambientalment beneficiós, com per exemple la utilització de termes com a "verd", "no contaminant" i "respectuós amb el planeta".
- La utilització de símbols és opcional quan es realitza una auto declaració mediambiental. Els símbols han de ser simples, diferenciables, fàcilment reproduïbles i amb una grandària i posició que s'acomodi al producte.

• Aquest tipus de declaracions no és susceptible, encara que sí preferible, d'una certificació d'una tercera part independent.

Una vegada establerts els requisits tenint en compte l'anteriorment comentat, tots els productes que compleixin amb aquests requisits es consideraran aptes per portar la auto declaració mediambiental.

Exemples:

Figura 16: Garantia de qualitat ambiental
Font: http://www.nosabesnada.com/uploads/2013/01/S%C3%ADmbolos-reciclaje-de-pl%C3%A1sticos-300x175.jpg a 18/06/2015

1.5.4 Eco-etiquetes tipus III o Declaracions Ambientals de Producte (DAP):

Les DAP o EPD (Environmental Product Declaration) en anglès, estan regulades per la norma ISO 14025. Consisteixen en la comunicació de dades ambientals quantitatives calculades d'un producte segons uns paràmetres prefixats basats en la sèrie de les normes 14040, referents a l'anàlisi del cicle de vida, així com la informació ambiental addicional subministrada dins d'un programa de declaració ambiental tipus III.

Aquest tipus de etiquetes són indicades per transaccions entre empreses i no pel consumidor final ciutadà per la seva complexitat, tot i que cada cop s'estan desenvolupant sistemes més fàcilment interpretables.

El propòsit d'una DAP en el sector de la construcció és proporcionar la base per avaluar edificis íntegrament i identificar aquells que causen menor pressió sobre el medi ambient, tot i que no estan obligades a ser verificades per un tercer.

Per a aquest propòsit, es fa ús de les Regles de Categoria de Producte, RCP, les quals tenen com a objectiu proporcionar unes regles que assegurin:

- la disponibilitat de dades verificables i coherents per una DAP (basats en un ACV).
- la disponibilitat de dades tècniques o escenaris verificables i consistents relacionats amb un producte per a l'avaluació del comportament ambiental d'edificis.
- la disponibilitat de dades tècniques relacionades amb el producte o els escenaris, verificables i coherents, per a avaluació del comportament ambiental dels edificis.
- que les comparacions entre els productes de construcció es duen a terme en el context de la seva aplicació a l'edifici.

Els tipus de DAP es defineixen en funció *l'abast del cicle de vida*[1]:

- Només l'etapa de producte. Aquesta DAP cobreix el subministrament de matèries primeres, el transport, la fabricació i els processos associats. Aquestes DAP es denominen "bressol a porta" i estan basades en els mòduls d'informació A1 a A3.
- L'etapa de producte i altres etapes seleccionades del cicle de vida. Aquestes DAP es denominen "cradle to gate with options" (bressol a porta amb opcions) i estan basades en els mòduls d'informació A1 a A3 a més d'altres mòduls opcionals seleccionats, per exemple els mòduls d'informació C1 a C4 (es pot incloure el mòdul d'informació D).

[1] S'explica més endavant en l'apartat 3.2 Fases del cicle de vida.

• El cicle de vida d'un producte d'acord als límits del sistema. Aquest tipus de DAP cobreix l'etapa de producte, la instal·lació a l'edifici, l'ús i manteniment, les substitucions, la demolició i el tractament de residus per a reutilització, recuperació, reciclat i eliminació. Aquestes DAP es denominen “bressol a tomba” i estan basades en un ACV, és a dir cobreixen tots els mòduls d'informació A1 a C4 (es pot incloure el mòdul d'informació D).

Només és obligatori declarar els mòduls de l'etapa de producte, A1A3, per al compliment de la norma UNE-EN ISO 15804.

Una Declaració Ambiental de Producte ha de contenir almenys els següents punts:

• Resum de les activitats, productes i serveis de l'organització.

• La política ambiental i una breu descripció del sistema de gestió ambiental de l'organització.

• Descripció de tots els aspectes ambientals directes i indirectes significatius.

• Descripció dels objectius i les metes ambientals en relació amb els aspectes i impactes ambientals significatius.

• Resum de les dades sobre els aspectes ambientals que permeti fer una comparació interanual de l'evolució del comportament ambiental.

• Informació del comportament de l'organització respecte a la legislació ambiental aplicable.

• Nom, nombre d'acreditació del verificador i data de validació.

Hi ha altres sistemes o programes DAP/EPD, cada una fa servir les seves pròpies RCP. Les més utilitzades a Espanya son:

Figura 17: Logo DAPc
Font: Agenda de la construcció sostenible, Barcelona (ES) / http://www.csostenible.net.

- Declaració Ambiental de Productes de la Construcció (DAPc):

  Declaració Ambiental de Productes de la Construcció i les DAPc sectorials, que son una variant de les DAPc que ens mostren els valors mitjans d'un producte amb característiques funcionals similars per sectors. Aquestes resulten especialment útils per conèixer l'impacte ambiental d'un producte tipus sense conèixer el model ni la marca exacta. són les utilitzades per donar forma a la base de dades d’aquest projecte.

- GLOBAL EPD D’AENOR:

  Aquest programa també s’especialitza en el sector de la construcció i una visió sectorial. Té com a característica que no està verificada per un tercer sinó per ells mateixos.

- ENVIRONDEC:

  També una de les més utilitzades amb seu a Stockholm, Suècia, Environdec és un dels grans organismes amb reconeixement internacional per la gestió de declaracions ambientals de producte, i hi ha un gran número d’empreses reconegudes per ells per exemple Isover.

2. Base de dades i programari:

2.1 Base de dades nacionals i internacionals:

Actualment l'ACV és una metodologia bàsica per l'eco-disseny. Existeixen ja bases de dades molt elaborades i completes així com eines informàtiques (programari) de suport per a l'avaluació d'impacte del cicle de vida fonamentalment. (EICV)

Les eines informàtiques comercials per ACV són principalment bases de dades que alimenten els algorismes d'un programari d'anàlisi.

Per a les bases de dades no existeix una valoració universalment acceptades de l'impacte ambiental que una determinada substància o un procés concret produeixen en una determinada regió en unes condicions determinades. Per tant les variables són tan àmplies que compliquen seriosament aquesta empresa.

Diferents bases de dades, encara que similars en el més transcendental, difereixen en el valor i algorisme utilitzat per a la determinació d'aquest, per a cada emissió, abocament o procés.

La facilitat que una base de dades ofereixi per a la inclusió de dades pròpies del dissenyador i fins i tot la possibilitat d'importar- exportar dades des de programes d'ús quotidià són característiques que diferencien una bona base de dades.

A continuació una llista de les principals bases de dades i una breu explicació:

Base de dades	Companyia	País	Més informació
ELCD	National Renewable Energy Laboratory	Europa	http://eplca.jrc.ec.europa.eu
U.S.L.C.I	National Renewable Energy Laboratory	Estats Units	http://www.nrel.gov/lci
Ecoinvent v3	Ecoinvent centre	Suïssa	http://www.ecoinvent.ch
Gabi database	PE International	Alemanya	http://www.gabisoftware.com/international/index

IVAM LCA Data	IVAM Environmental Research	Holanda	http://www.ivam.uva.nl/en
Athenadatabase	AthenaInstitute	Canadà	http://www.athenasmi.org
ETH-ESU	ETH-ESU	Suïssa	http://www.uns.ethz.ch
GEMIS 4.5	Öko-Institut	Alemanya	http://www.iinas.org/gemis.html
BEDEC	Institut Tecnològic de la Construcció de Catalunya, ITeC	Espanya	http://itec.es

Taula 1: Bases de dades més reconegudes

Font: Pròpia.

- ELCD (EuropeanLifeCycleDatabase):
  Conté materials, transformació d'energia, transport i gestió de residus. Les dades de la base són oficialment proporcionats i aprovats pel gremi industrial corresponent a cada família de materials.

- USLCI (U.S. LifeCycleInventory):
  És una base de dades nord-americana que inclou fluxos d'energia i materials per als processos unitaris més comuns. Tant la base de dades ELCD com la USLCI no tenen una distinció per localitat, la ELCD són dades mitjanes europeus i la USLCI són dades mitjanes americans.

- Ecoinvent:
  És una de les bases de dades més utilitzades mundialment i la que hem utilitzat per llençar les nostres simulacions en el nostre projecte. Aquesta conté gran varietat de processos incloent energia, transport, materials de construcció, productes químics, agricultura, gestió de residus i altres. Llançada al maig del 2013, és una de les versions més actuals que trobem i amb més de 8.000 referències de dades, molts més dades que altres bancs de dades.

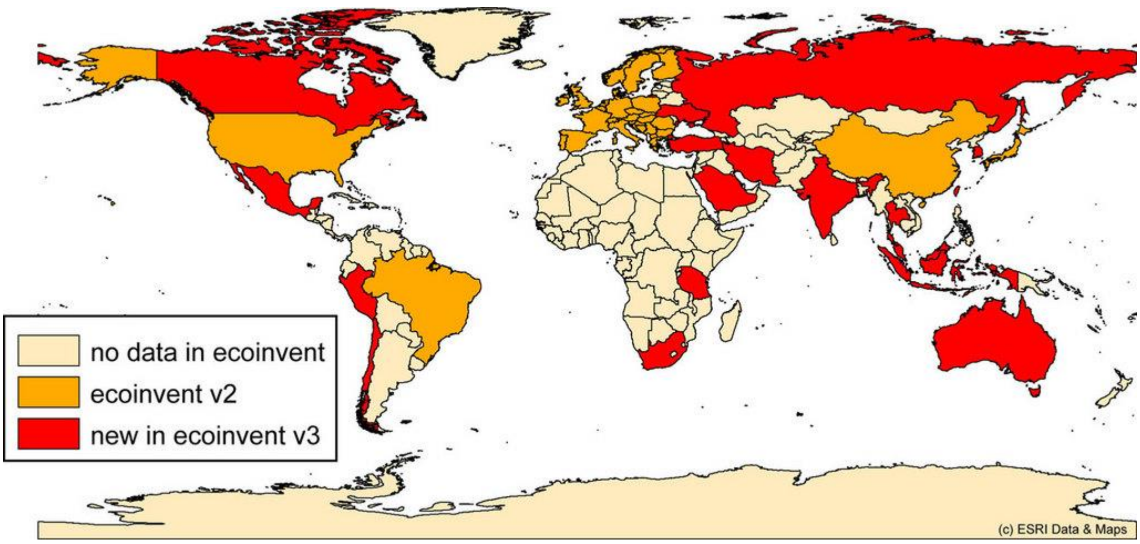


Figura 18: Disponibilitat de la base de dades Ecoinvent v3
Font: Pré-Sustainability (2014); Webinar SimaPro, Iavola: Barcelona (ES)

- Gabi database:

  Inclou processos del sector agrícola, de la construcció, productes químics, electrònica i Tics, energia, alimentació, metalls, mineria, productes industrials, plàstics, i altres. És una base de dades molt elaborada i amb molta informació, el problema resideix en la compatibilitat amb el programari. L'empresa PE Internacional a part de ser la desenvolupadora de la base de dades Gabi, també programa un programari de càlcul d'emissions amb el mateix nom i això fa que per poder obtenir les dades sobre aquest banc de dades sigui necessària la llicència del seu programari personal.

- BEDEC:

  No és solament una base de dades de preus per a pressupostos, també inclou les dades mediambientals dels productes de manera genèrica. L'objectiu d'aquest projecte és posar en crisi aquestes mateixes dades i substituir-los i ampliar-los amb noves dades i nous indicadors ambientals.

  Aquestes últimes cinc bases de dades són les més reconegudes a nivell nacional i fins i tot a nivell internacional. Per això, són les que s'han proposat utilitzar per a la realització del projecte. La base de dades Gabi, ha estat descartada ja que el programari SimaPro ens ofereix una compatibilitat major amb Ecoinvent que amb Gabi programari.

La resta de banc de dades té una participació menor en quant a nombre de processos:

- IVAM LCA Data:
  Conté dades holandeses sobre materials, producció de combustibles i energia.

- Athena database:
  Conté consums energètics i emissions de productes de la construcció al llarg de la seva vida útil.

- ETH-ESU:
  Àmplia base de dades suïssa centrada en energia, transports i residus.

- GEMIS 4.5:
  Base de dades gratuïta que engloba processos energètics i de transport, materials, processos de reciclatge i de tractament de residus.

2.2 Programari:

En els últims anys i basats en la metodologia de l'ACV s'ha desenvolupat nombrosos programes per facilitar el seu càlcul. La majoria d'aquests programes inclouen bases de dades que poden variar en extensió i qualitat de les dades i per tant en el preu. Les bases de dades d'inventaris públics venen incorporades en la majoria de programes comercials.

En ells s'introdueixen les dades que configuren l'inventari per posteriorment realitzar els càlculs propis de la fase de l'EICV, obtenint així els resultats per les diferents categories d'impacte escollides.

Els Programaris comercials més destacats són:

Software	Companyia	País	Més informació
Gabi	Stuttgart University	Alemanya	www.gabi-software.com
SimaPro	Pré Consultants	Netherlands	www.pre.nl
LCAit	Chalmers Industritenik	Suècia	www.ekologik.cit.chalmers.es
Umberto	Ifeu-Institut	Alemanya	www.ifeu.de/umberto.htm
TEAM	Ecobalance	França	www.pwcglobal.com
NIRE-LCA 2	NationalInstitute for Resourcesand Environmental	Japó	http://www.aist.go.jp
Repaq.ltd	Franklin Associated	Estats Units	http://www.fal.com

Taula 2: Programari més reconegut

Font: Pròpia

- Gabi: desenvolupat a Alemanya i comercialitzat per IPTS. Aquest programa permet recrear processos simples i processos parametritzats que permeten simular entrades i sortides més complexes i fins i tot associar costos als fluxos.

- SimaPro: desenvolupat a Holanda i comercialitzat per Pré consulting. Es pot realitzar un mateix ACV amb diferents mètodes per a avaluació d'impactes, permet calcular els impactes segons sèries de normes ISO 14040.

- LCAiT: desenvolupat a Suècia i comercialitzat per ChalmersIndustrifeknik. Està basat en el model SPINE (Sustainableproductinformation network for theenviroment), format per a l'emmagatzematge, administració i recuperació de les dades d'inventari.

- Umberto: desenvolupat a Alemanya i comercialitzat per IFEU. Es caracteritza per la seva gran qualitat de dades i transparència dels resultats. Té una gran llibreria de processos estàndard.

- TEAM: comercialitzat per Ecobalance, amb origen compartit Europeu-Estatunidenc. És un dels programes més potents i flexibles. No disposa de guia passo a pas i permet la introducció d'informació relativa a costos.

- NIRE-LCA 2: desenvolupat a Japó i comercialitzat per: NationalInstitute for ResourcesandEnvironmental. Programari utilitzat extensament en la indústria japonesa per a la implantació del ACV.

- Repaq.ltd. Desenvolupat en I.I.O.O. i comercialitzat per Franklin Associated.

2.3 SimaPro

Desenvolupat per la consultora holandesa Pré Consultants, SimaPro és l'eina informàtica d'Anàlisi del Cicle de Vida de referència a tot el món, amb usuaris en més de 60 països, i el seu distribuïdor a Espanya es lavola.

Figura 19: Usuaris SimaPro i ampreses assossiades

Font: http://www.to-be.it / a data: 12/05/2015

SimaPro disposa de les bases de dades ambientals internacionals més reconegudes actualment com Ecoinvent, USCLI, Methods i ELCD.

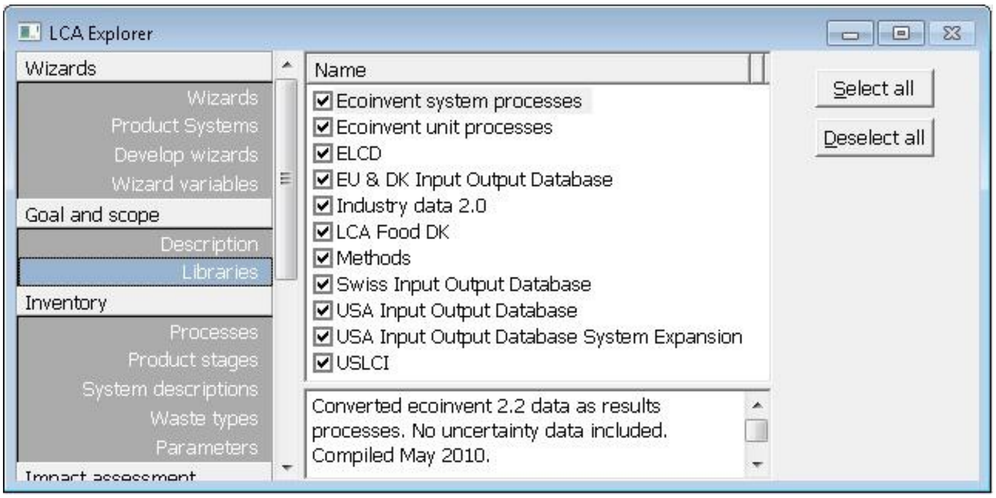


Figura 15: Base de dades SimaPro

Font: Pròpia

Per els nostres càlculs s'ha utilitzat la base de dades Ecoinvent perquè és àmpliament reconeguda com la major i més consistent base de dades d'ICV del mercat a més a més, la base de dades conté informació per a la majoria de les indústries i ofereix actualitzacions freqüents, tan aviat com les noves dades es troben disponibles.

-Consideracions alhora d'extreure les dades:

Alhora de buscar un material amb SimaPro, s'ha de tenir en consideració una sèrie de nomenclatures que ens donen una informació sobre quines dades hi ha en aquell material. Les dades d'Ecoinvent queden separades a nivell de mercat o producció i cadascuna d'elles segons la seva localització.

Localització; RER, ROW, GLO, ES/CH:

Quan es busca un material cal saber d'on prové. La localització d'un material ens indica el seu lloc d'origen i per tant es molt important escollir bé, doncs no té el mateix impacte un objecte construït amb materials autòctons, que amb materials importats des d'un altre país.

- **{RER}:**
  Materials amb dades generals localitzades a Europa. Tots els materials amb aquesta nomenclatura dins de la base de dades Ecoinvent, s'han recollit com a vàlids per modificar-los i especificar-los a la nostra localització.

- **{ROW}:**
  Materials amb dades generals localitzades fora d'Europa (Rest Of the World). Tots aquests materials s'han desestimat com a vàlids en la nostra base de dades, tret que es tracti d'un component o un material generalment importat de fora la Unió Europea.

- **{GLO}:**
  Materials dels quals no es té dades localitzables geogràficament o que són la combinació dels materials de procedència europea i els de procedència estrangera amb l'objectiu de generar unes dades genèriques (Global).

- **{ES} / {CH}:**

Materials amb dades generals, contrastats amb els gremis del sector, localitzats en un país en concret (Espanya i Suïssa). Tot material que s'ha modificat per a la seva major aproximació a la realitat del nostre país, ha obtingut aquesta nomenclatura. Tanmateix hi ha molts més països en la base de dades, per exemple Xina{CN}, República Txeca{CZ} etc.

Market/Production:

Ecoinvent fa una distinció significativa dels materials que formen la seva base de dades en funció dels inputs considerats, doncs no té la mateixa computació un producte a nivell de la seva producció que a nivell de marcat.

- ***Market***: Els materials a nivell de mercat tenen associat una combinatòria de materials locals i externs {RER},{ROW} i el seu mixt de transport (explicat més endavant) amb vehicles pesants, trens o vaixells, i per tant ja ens ve computat les emissions realitzades pel transport.
  Aquests materials no ens interesant pel nostre projecte ja que intentem realitzar una base de dades el més proper a la realitat d'Espanya com sigui possible.

- ***Production**:* Els materials a nivell de producció tenen una localització específica, una tecnologia i una eficiència pròpia de cada país que ens permet acotar molt millor.

En el nostre projecte s'ha procurat agafar tots els materials en {ES} o {RER} i a nivell de *production* i s'ha modificat les eficiències de les infraestructures segons els organismes col·laboradors amb nosaltres. Tanmateix hem trobat casos en els que un material no es trobava en concepte de {ES}, la metodologia es basava en buscar un país proper (per exemple Suïssa {CH}) informar-nos de les diferències tecnològiques entre el nostre país i l'altre, i modificar manualment els paràmetres per crear un "{ES}" propi.

Els mètodes que contempla SimaPro:

Una diferència important entre els diferents mètodes d'avaluació d'impactes resideix en l'opció d'analitzar l'efecte últim de l'impacte ambiental, endpoint, o bé, considerar els efectes intermedis, midpoints. Les categories d'impacte ambiental intermèdies es troben més properes a la intervenció ambiental, permetent, en general, models de càlcul que s'ajusten millor a aquesta intervenció. Aquestes proporcionen una informació més detallada sobre de quina manera i en quin punt es afecta el medi ambient. Les categories d'impacte finals són variables que afecten directament a la societat, per tant la seva elecció resultaria més rellevant i comprensible a escala global. No obstant això, la metodologia per arribar a quantificar l'efecte últim no està plenament elaborada, no existeix el suficient consens científic. Per tot això, actualment, és més comú recórrer a categories d'impacte intermèdies.

Els mètodes que ens permet carregar SimaPro són els següents:

Midpoint methods:

- CML-IA
- EDIP 2003
- EPD (2013)
- ILCD 2011
- ReCiPeMidpoint
- BEES+
- TRACI 2.1
- CumulativeEnergyDemand
- CumulativeExergyDemand
- Ecologicalfootprint
- EcosystemDamagePotential
- Greenhouse Gas Protocol
- IPCC 2013
- USEtox
- Water footprint: Boulay et al 2011 (Water Scarcity)
- Water footprint: Berger et al 2014 (Water Scarcity)
- Water footprint: Ecological Scarcity 2006 (Water Scarcity)
- Water footprint: Hoekstra et al 2012 (Water Scarcity)
- Water footprint: Pfister et al 2009 (Water Scarcity)

Endpoint methods

- Ecologicalscarcity 2013
- EPS 2000
- ReCiPeEndpoint
- IMPACT 2002+
- Water footprint: Boulay et al 2011 (Human Health)
- Water footprint: Motoshita et al 2010 (Human Health)
- Water footprint: Pfister et al 2009 (Eco-indicator 99)
- Water footprint: Pfister et al 2010 (ReCiPe)

3. ANÀLISIS CRÍTIC DE DADES MEDI AMBIENTALS

3.1 Mòduls d'informació del cicle de vida:

L'anàlisi del cicle de vida (ACV)s'ha d'entendre com el cicle complet des de l'extracció de les matèries primeres fins a la fi de la vida d'aquests recursos, conegut com el "cradle"(lit. Bressol) to "grave"(lit. Tomba), és dir, des de l'inici fins el final, o del bressol a la tomba. En tot aquest cicle hi ha unes fases que ens determinen la situació en la que ens trobem identificades per una nomenclatura alfa-numèrica. Fase d'extracció (A1-A3), fase de producció (A4-A5), fase d'ús (B1-B7), fase del fi de vida (C1-C4), i reutilització, recuperació o reciclatge (D)

En funció de l'abast de l'anàlisi del cicle de vida (ACV) es diferencien quatre etapes que determinen de menor a major l'abast d'aquest:

1. **Cradle to grave:**

Literalment del bressol a la tomba fa referència al cicle de vida complet des de l'extracció dels recursos fins la fase d'eliminació (grave). Cobreix tots els mòduls del cicle de vida com a mínim, incloent la fase final de la seva vida útil C1-C4, mòdul D pot ser inclòs.

2. **Cradle to gate:**

És l'anàlisi parcial del cicle de vida d'un producte des de l'extracció/bressol (cradle) fins la porta (gate) de la fàbrica (abans de ser transportat al consumidor final). La fase d'ús i la d'eliminació no es tenen en compte. Ha de cobrir els mòduls de l'A1-A3, això inclou el mínim de processos que requereix segons la EN 15804: 2012.

3. **Cradle to gate with options:**

És el mateix anàlisi parcial del cicle de vida que el Cradle to gate amb informació afegida de la fase d'ús (B1-B7) i la de fi de vida (C1-C4), mòdul D pot ser inclòs.

4. **Cradle to cradle:**

També anomenada del bressol al bressol, cal entendre-la com a una proposta de màxims en l'anàlisi del cicle de vida. En els anteriors casos es tracte de disminuir els impactes mitjançant aquests estudis parcials del cicle de vida total amb la consigna principal de reduir, reutilitzar o reciclar. Davant d'aquest panorama el cradle to cradle pretén actuar sobre l'arrel del problema, és a dir, que en comptes de reduir els consums d'energia, ens centrem que en que des del propi disseny i concepció de qualsevol producte, estratègia o política es tinguin en compte totes les fases dels productes involucrats (extracció, processament, utilització, reutilització, reciclatge...) de manera que ni tan sols siguin necessaris les despeses d'energia, fins i tot que el balanç de despeses i aportacions sigui positiu, i que per tant des del disseny ja es tingui en compte com reutilitzar-ho. Portat a un exemple pràctic això implicaria que si un edifici gasta molta energia amb l'aire condicionat i la il·luminació, en comptes de (o millor alhora que) optimitzar el rendiment de la maquinària i la instal·lació de panells fotovoltaics, proposen concebre l'edifici des del seu inici plantejant-se l'aprofitament de la ventilació creuada i de la il·luminació natural, per no necessitar la despesa d'energia que es produiria d'una altra forma. Fins i tot l'edifici produiria més energia de la qual consumeix (i depuraria l'aigua que passa per ell, etc), tanmateix s'hauria de tenir en compte la fase de desconstrucció del mateix doncs tot estaria pensat prèviament. En realitat és tracte de tancar el cercle del cicle de vida, que al final tot acabi al mateix punt de partida i en global no generar cap saldo negatiu en els impactes ambientals.

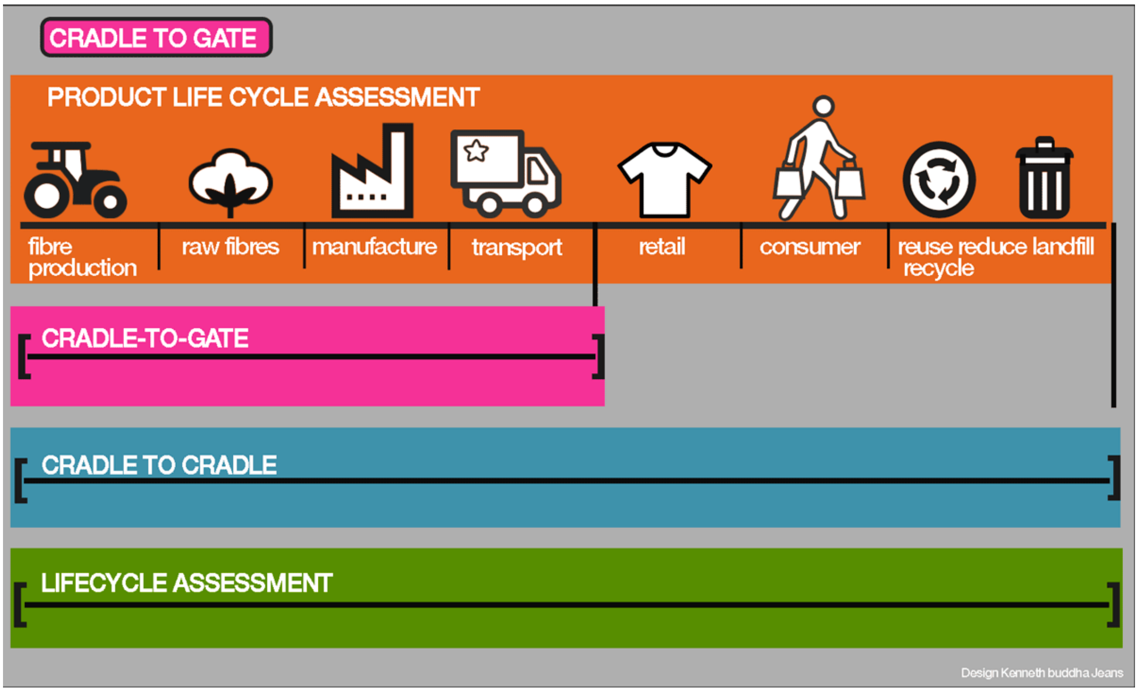
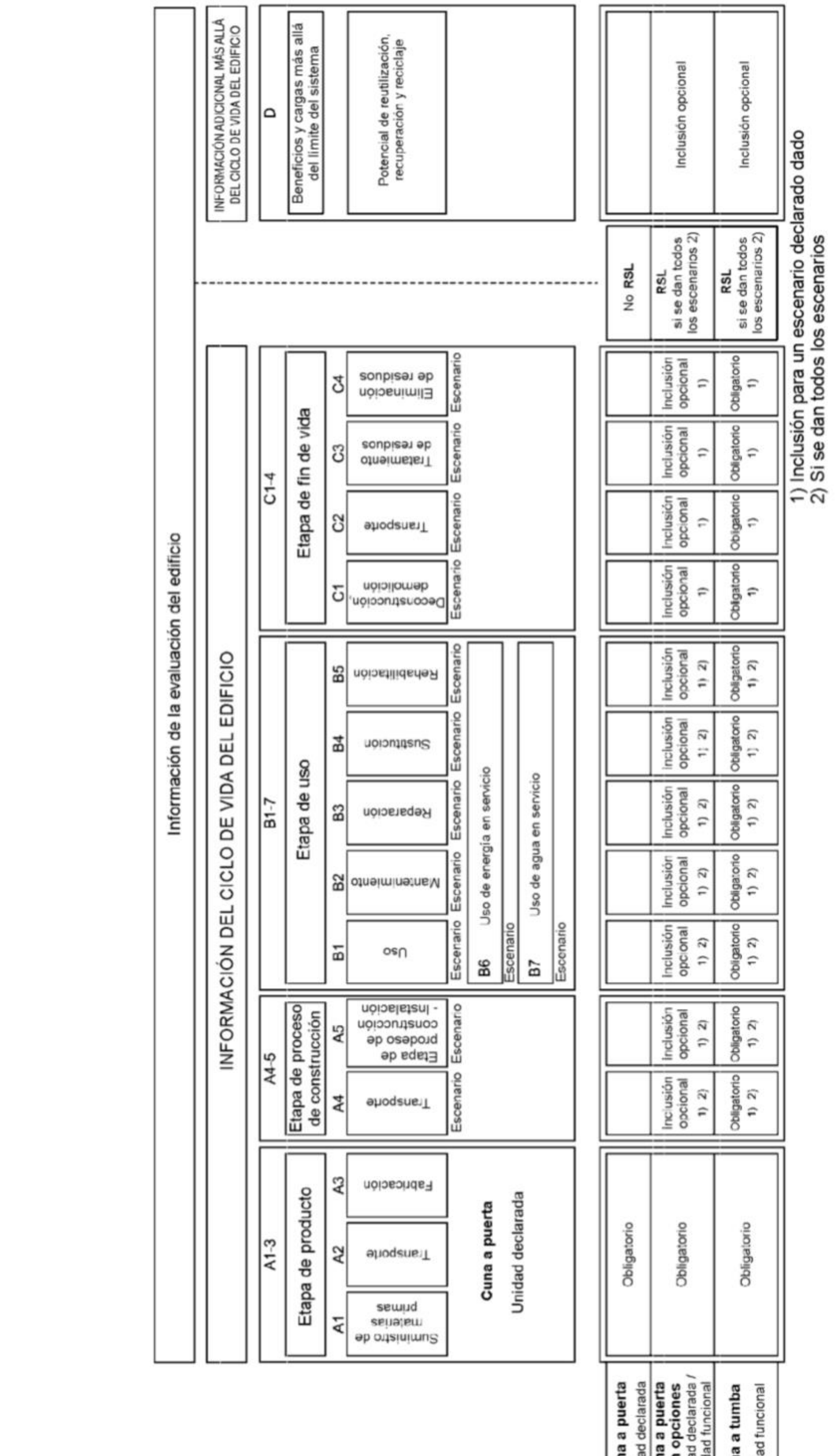


Figura 20: Abast del ACV

Font: http://buddhajeans.com/sustainable-fashion-design-contents-page/diagram-downloads-library/lca-life-cycle-assessment-diagram-library/ a data: 02/05/2015

En el nostre estudi em pres com a referència i per tant s'han realitzat els càlculs, seguint les RCP (regles de categoria de producte) de les DAP tipus cradle to gate with options (del bressol a la porta amb opcions) ja que amb l'estructura actual de la base de dades, es complicat associar el consum relacionat a l'ús si no es manté una supervisió constant d'aquest, i s'ha tingut en compte informació sobre la fase de fi de vida o reciclatge (que serien les opcions).



Información de la evaluación del edificio
INFORMACIÓN DEL CICLO DE VIDA DEL EDIFICIO
INFORMACIÓN ADICIONAL MÁS ALLÁ DEL CICLO DE VIDA DEL EDIFICIO
A1-3
Etapa de producto
A1 Suministro de materias primas
A2 Transporte
A3 Fabricación
Cuna a puerta
Unidad declarada
A4-5
Etapa de proceso de construcción
A4 Transporte
A5 Etapa de prodeso de construcción - Instalación
B1-7
Etapa de uso
B1 Uso
B2 Mantenimiento
B3 Reparación
B4 Sustitución
B5 Rehabilitación
B6 Uso de energía en servicio
B7 Uso de agua en servicio
C1-4
Etapa de fin de vida
C1 Deconstrucción, demolición
C2 Transporte
C3 Tratamiento de residuos
C4 Eliminación de residuos
Escenario
D
Beneficios y cargas más allá del límite del sistema
Potencial de reutilización, recuperación y reciclaje
DAP
Cuna a puerta
Unidad declarada
Cuna a puerta con opciones
Unidad declarada / Unidad funcional
Cuna a tumba
Unidad funcional
Obligatorio
Inclusión opcional 1) 2)
Obligatorio 1) 2)
Inclusión opcional 1)
Obligatorio 1)
No RSL
RSL si se dan todos los escenarios 2)
Inclusión opcional
1) Inclusión para un escenario declarado dado
2) Si se dan todos los escenarios

3.2 Fases del cicle de vida:

La informació ambiental d'una DAP que cobreix totes les etapes del cicle de vida (del bressol a la tomba) s'ha de subdividir en els grups de mòduls d'informació A1-A3, A4-A5, B1-B5, B6-B7, C1-C4 i el mòdul D, com està estipulat en la normativa UNE-EN 15804:2012.

Només és obligatori declarar els mòduls d'etapa de producte de l'A1-A3, pel compliment de la norma. La declaració de la resta de mòduls és opcional.

3.2.1 Fase de producte: A1 – A3

La fase de producte és una fase d'informació que ha d'incloure's a qualsevol declaració ambiental de producte (DAP), i inclou els mòduls d'informació A1 a A3.

S'inclouran aquells processos que van des de les entrades de matèria primera i energia en el sistema, i els processos posteriors de fabricació i transport fins a la porta de la fàbrica (craddle to gate), també queden inclosos els tractaments dels residus generats per aquests processos.

Cal recordar que l'anàlisi del cicle de vida (ACV) és un procés iteratiu, per exemple, si bé un llapis com a producte acabat té en la matèria prima la mina i la fusta (A1-A3), la mina com a producte acabat tindrà en la fase A1-A3 el grafit i argila.

Figura 21:

Font: etool, Australia, Canberra (AW) / http://etoolglobal.com/

A1: Extracció i processat de les matèries primeres.

Processat de les entrades que constitueixin materials secundaris (per exemple, processos de reciclatge).

A2: Transport al fabricant (també es contempla el transport intern).

A3: Fabricació.

Els mòduls A1, A2 i A3 es poden declarar com un mòdul integrat A1-3.

3.2.2 Fase de construcció: A4-A5

Inclou el subministrament de tots els materials, productes i energia, així com el tractament de residus fins el estat de fi de residu o l'eliminació del residu final durant l'etapa de procés de construcció. Aquests mòduls de informació inclouen també tots els impactes i aspectes relacionats amb les pèrdues en l'etapa del procés de construcció (es a dir, la producció, el transport, el tractament de residus i la eliminació dels productes i matèria perduda).

Figura 22:

Font: etool, Australia, Canberra (AW) / http://etoolglobal.com/

A4: Transport a l'obra.

A5: Instal·lació del producte a l'edifici, incloent la fabricació i transport dels materials auxiliars i qualsevol energia o aigua necessàries per a la instal·lació o el funcionament de l'obra. S'inclouen també les operacions in situ del producte.

3.2.3 Fase d'ús: B1-B7

L'etapa d'ús conté els mòduls d'informació opcionals que cobreix el període comprès entre el producte acabat fins que es desconstrueix.

També inclou la seva utilització per protegir, conservar, gestionar o controlar un edifici, per exemple els mòduls que descriuen el funcionament de l'edifici a través de serveis vinculats a l'edifici tals com a calefacció, refrigeració, il·luminació, subministrament d'aigua i transport intern, proporcionat per exemple per ascensors i escales mecàniques. A més, el manteniment, la reparació, la substitució i la rehabilitació estan contemplades en aquesta fase.

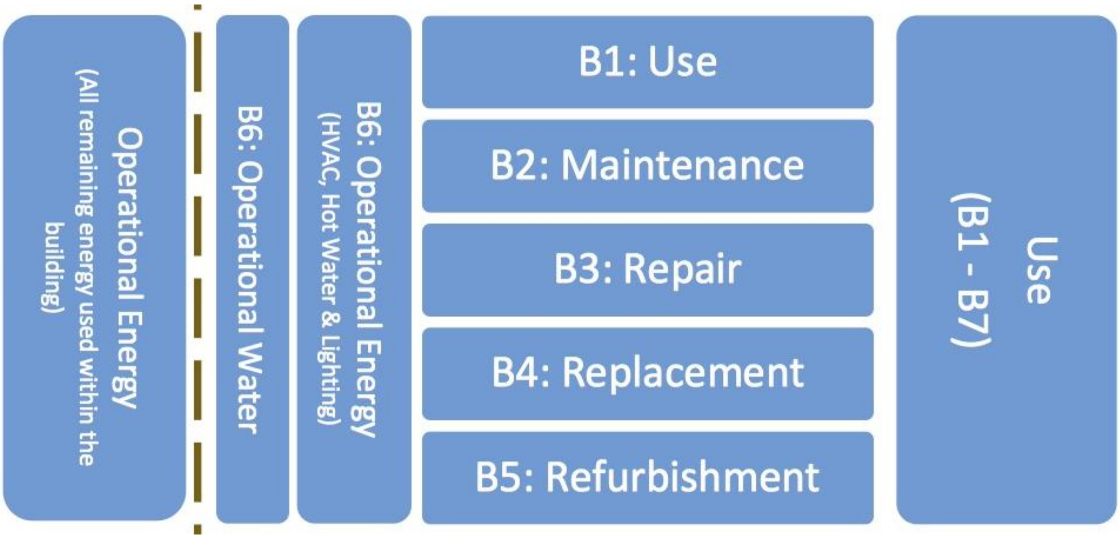


Figura 23:
Font: etool, Australia, Canberra (AW) / http://etoolglobal.com/

B1: Ús o aplicació del producte instal·lat.

> *Cobreix els aspectes i impactes derivats dels components de l'edifici o de l'obra de construcció durant el seu ús normal o previst.*

B2: Manteniment

> *Abasta la combinació de totes les accions tècniques i administratives associades planificades durant la vida útil per mantenir el producte instal·lat en un edifici, una obra de construcció o una part de l'edifici o l'obra, en un estat en el qual pugui aconseguir el seu comportament funcional i tècnic necessaris, així com preservar les qualitats estètiques del producte.*
>
> *Inclou les activitats de manteniment preventiu i regular com la planificació de la neteja, la cura, la substitució o reparació de peces desgastades, danyades o*

degradades. A més, s'inclou en aquest mòdul d'informació l'ús d'aigua i energia necessari per a la neteja com a part del manteniment.

La producció, el transport al lloc en què es realitza el manteniment, el posterior transport de tots els residus vinculats i els processos de finalització de vida de qualsevol component i producte auxiliar utilitzats per al manteniment (incloent neteja), queden comptabilitzats en aquest mòdul d'informació.

B3: Reparació

Cobreix una combinació de totes les accions administratives i tècniques realitzades durant la vida útil associades al tractament correctiu i preventiu d'un producte de construcció o de les seves peces instal·lades a l'edifici o en l'obra de construcció per recuperar una condició acceptable que li permeti aconseguir els comportaments funcional i tècnic requerits. A més, cobreix la preservació de les qualitats estètiques del producte.

La producció, el transport al lloc en què es realitza el manteniment, el posterior transport de tots els residus vinculats i els processos de finalització de vida de qualsevol component i producte auxiliar utilitzats per a la reparació, queden comptabilitzats en aquest mòdul d'informació.

B4: Substitució

Abasta la combinació de totes les accions administratives i tècniques realitzades durant la vida útil per a la tornada d'un producte de construcció a un estat que li permeti aconseguir el comportament funcional i tècnic requerit, mitjançant la substitució completa d'un element de construcció.

La substitució d'un component, o d'una part, trencat a causa dels danys hauria de considerar-se com a reparació, però si es realitza una substitució de tot un element de construcció s'ha de considerar com a substitució. La substitució completa d'un element de construcció es considerarà com a rehabilitació.

La producció, el transport al lloc en què es realitza el manteniment, el posterior transport de tots els residus vinculats i els processos de finalització de vida de qualsevol component i producte auxiliar utilitzats per a la substitució, queden comptabilitzats en aquest mòdul d'informació.

B5: Rehabilitació

És la combinació de totes les accions administratives i tècniques realitzades durant la vida útil d'un producte per retornar un edifici o una altra obra de construcció, o les seves parts, a un estat que li permeti realitzar les seves funcions requerides. Aquestes activitats inclouen un programa concertat de manteniment, reparació i/o substitució, sobre una part significativa o una secció completa de l'edifici.

La producció, el transport al lloc en què es realitza el manteniment, el posterior transport de tots els residus vinculats i els processos de finalització de vida de qualsevol component i producte auxiliar utilitzats per a la rehabilitació, queden comptabilitzats en aquest mòdul d'informació.

Els següents mòduls d'informació (B6 i B7), són independents als anteriorment comentats i per tant, no es consideren mòduls lineals, és a dir, no es produeixen al final de l'etapa de vida del producte, sinó que succeeixen de manera paral·lela.

B6: Ús de l’energia en servei

Els sistemes tècnics integrats a l'edifici s'instal·len com a suport de l'edifici o d'una obra de construcció. Això inclou sistemes tècnics de construcció per a la calefacció, refrigeració, ventilació, il·luminació, aigua calenta sanitària, ACS, i altres sistemes de sanejament, seguretat, seguretat contra incendis, transport intern i l'automatització d'edificis i control de les tecnologies de la informació i la comunicació, TIC

En aquest mòdul d'informació s'estudia únicament l'ús de l'energia i els residus que això pot provocar, els aspectes relacionats amb la producció, el transport, instal·lació dels equips necessaris per al subministrament, l'ús de l'energia per als mòduls d'informació B2-B5 i els aspectes relacionats amb el tractament de residus i l'eliminació final dels equips, no es designaran a aquest mòdul.

B7: Ús de l’aigua en servei.

El límit d'aquest mòdul d'informació (consum d'aigua en servei) ha d'incloure l'ús de l'aigua durant el funcionament del producte, juntament amb els seus aspectes i impactes ambientals associats, tenint en compte el cicle de vida de l'aigua que inclou la producció i el transport de l'aigua i el tractament d'aigües residuals.

Els sistemes tècnics integrats a l'edifici són els equipaments tècnics que s'instal·len com a suport al funcionament de l'edifici. Això inclou els sistemes de refrigeració, *la ventilació, la humectació, l'aigua calenta sanitària, ACS, i altres sistemes tècnics de sanejament, la seguretat, la protecció contra incendis i el transport intern.*

3.2.4 Fase fi de vida: C1-C4

La fase de finalització de vida del producte de construcció s'inicia quan se substitueix, es desmunta o és deconstruit de l'edifici o l'obra de construcció i no presenta cap funcionalitat addicional.

Totes les sortides del desmantellament, desconstrucció o demolició de l'edifici, dels processos de manteniment, reparació, substitució o la rehabilitació, totes les deixalles, tots els productes de construcció, materials o elements de construcció, etc. que surten de l'edifici, es consideren en un primer moment residus.

Figura 24:
Font: etool, Australia, Canberra (AW) / http://etoolglobal.com/

C1: Desconstrucció i demolició.

C2: Transport fins l'emplaçament de tractament de residus.

C3: Tractament de residus per a la seva reutilització, recuperació i/o reciclatge.

C4: Eliminació incloent el pretractament físic i la gestió en el lloc d'eliminació.

Les emissions produïdes per l'eliminació de residus en el mòdul d'informació C4 es consideren part del sistema del producte d'estudi, segons el principi el que contamina paga. No obstant això, si aquest procés genera energia com la calor i l'energia elèctrica procedent de la incineració de residus o l'emmagatzematge en *abocador, els beneficis potencials de la utilització d'aquesta energia en el següent sistema del producte s'assignen al mòdul d'informació D i es calculen utilitzant processos mitjans de substitució vigents.*[2]

3.2.5 Beneficis i càrregues més enllà dels límits del sistema: D

El mòdul d'informació D cerca la transparència dels beneficis o càrregues ambientals generats pels productes reutilitzables, materials reciclables i/o vectors energètics útils procedents del sistema del producte, per exemple en forma de materials o combustibles secundaris. Tots els beneficis declarats obtinguts dels fluxos nets que abandonen el sistema del producte que no s'han assignat entre co-productes i que han aconseguit l'estat de finalització de residu s'han d'incloure en aquest mòdul d'informació.

Figura 25:

Font: etool, Australia, Canberra (AW) / http://etoolglobal.com/

D: Potencial de reutilització, recuperació i/o reciclatge, expressat com a càrregues i beneficis nets.

[2] Informació extreta de la ISO 15804:2012

3.3 Materials físics o primaris

Per realitzar la nova base de dades medi ambiental, es va fixar com a objectiu realitzar els materials físics o primaris del banc BEDEC per poder, posteriorment, agrupar-los i crear un altres elements i/o sistemes constructius.

D'aquesta manera només caldria centrar-nos en 154 enlloc dels més de 700.000 que el BEDEC conté entre partides d'obra i materials (tant primaris com elaborats), i alhora seria més simple en cas de voler-se afegir un nou material ja que només caldria crear-lo a partir dels primaris.

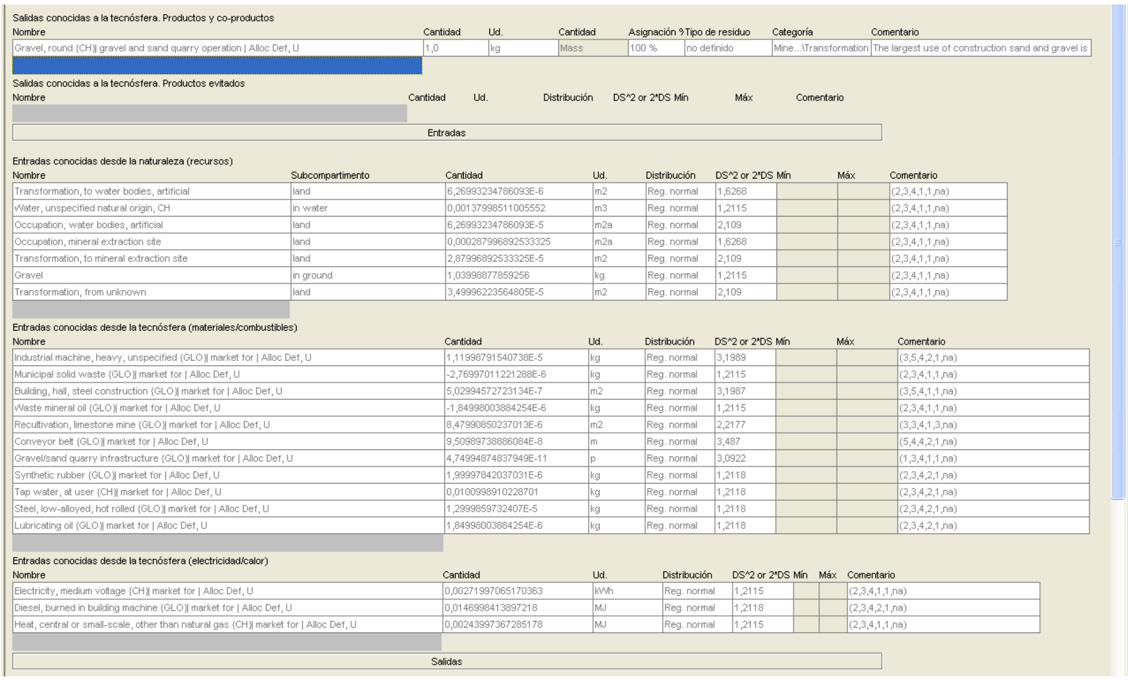
Per a la realització de la cerca d'informació, es necessita saber quina tecnologia, el tipus de processos d'extracció i de producció, i el lloc d'estudi que precisa cada material ja que la tecnologia pot variar en funció del país o la regió. A causa de la gran quantitat d'informació que s'ha fer servir, aquesta base de dades s'ha dividit en dues parts per realitzar els anàlisis amb un altre company. La família de materials de la qual jo he estat responsable en aquest projecte, és la família de les ceràmiques i els plàstics. Altres grups com a additius o elements químics difícilment categorizables amb grans famílies de materials han estat realitzats a mesura que s'elaboraven les grans famílies.

En primer lloc cal reconèixer els processos necessaris per a la realització d'un quilogram (depenent de la seva unitat funcional, també podem trobar segons la seva superfície, el seu volum i fins i tot la distància recorreguda).

Després cal separar els materials físics primaris dels que estan en categoria de primaris en l'estructuració del banc BEDEC, però que són producte d'una composició entre materials o que han patit un procés per a la seva producció o fabricació, per posar un exemple, el acer al carbó el consideraríem un material primari però l'acer cadmiat seria el primer més un procés i el cadmi. Aquells materials que precisin d'altres elements que no apareguin en la taula anterior, tals com a productes químics o embalatges, s'afegiran com a material físic o primari.

Es realitza aquest mètode de separació de dades perquè el programari SimaPro, treballa amb una estructura d'arbre, és a dir que d'un material poden penjar molts altres materials per culpa, per exemple, del transport i l'energia. En el cas del transport, el programari genera un perfil de vehicle amb un pes específic i conformat per diferents materials com poden ser acer (estructura del vehicle), goma (pneumàtics)… El mateix succeeix amb l'energia, ja que aquesta compta amb una infraestructura (en aquest cas una central elèctrica) que també consta de materials i d'energia d'extracció, transport, fabricació i ús. Amb aquest sistema de càlcul podem arribar fins al nivell de procedència més primitiu i permetre'ns generar unes dades ambientals molt més precises.

L'entrada d'informació a SimaPro és complexa ja que consta de diferents entrades en les que cal introduir les dades.



Salidas conocidas a la tecnósfera. Productos y co-productos

Nombre	Cantidad	Ud.	Cantidad	Asignación %	Tipo de residuo	Categoría	Comentario
Gravel, round {CH}| gravel and sand quarry operation | Alloc Def, U	1,0	kg	Mass	100 %	no definido	Mine...\Transformation	The largest use of construction sand and gravel is

Salidas conocidas a la tecnósfera. Productos evitados

Nombre	Cantidad	Ud.	Distribución	DS^2 or 2*DS	Mín	Máx	Comentario

Entradas

Entradas conocidas desde la naturaleza (recursos)

Nombre	Subcompartimento	Cantidad	Ud.	Distribución	DS^2 or 2*DS	Mín	Máx	Comentario
Transformation, to water bodies, artificial	land	6,26993234786093E-6	m2	Reg. normal	1,6268			(2,3,4,1,1,na)
Water, unspecified natural origin, CH	in water	0,00137998511005552	m3	Reg. normal	1,2115			(2,3,4,1,1,na)
Occupation, water bodies, artificial	land	6,26993234786093E-5	m2a	Reg. normal	2,109			(2,3,4,1,1,na)
Occupation, mineral extraction site	land	0,000287996892533325	m2a	Reg. normal	1,6268			(2,3,4,1,1,na)
Transformation, to mineral extraction site	land	2,87996892533325E-5	m2	Reg. normal	2,109			(2,3,4,1,1,na)
Gravel	in ground	1,03998877859256	kg	Reg. normal	1,2115			(2,3,4,1,1,na)
Transformation, from unknown	land	3,49996223564805E-5	m2	Reg. normal	2,109			(2,3,4,1,1,na)

Entradas conocidas desde la tecnósfera (materiales/combustibles)

Nombre	Cantidad	Ud.	Distribución	DS^2 or 2*DS	Mín	Máx	Comentario
Industrial machine, heavy, unspecified {GLO}| market for | Alloc Def, U	1,11998791540738E-5	kg	Reg. normal	3,1989			(3,5,4,2,1,na)
Municipal solid waste {GLO}| market for | Alloc Def, U	-2,76997011221288E-6	kg	Reg. normal	1,2115			(2,3,4,1,1,na)
Building, hall, steel construction {GLO}| market for | Alloc Def, U	5,02994572723134E-7	m2	Reg. normal	3,1987			(3,5,4,1,1,na)
Waste mineral oil {GLO}| market for | Alloc Def, U	-1,84998003884254E-6	kg	Reg. normal	1,2115			(2,3,4,1,1,na)
Recultivation, limestone mine {GLO}| market for | Alloc Def, U	8,47990850237013E-6	m2	Reg. normal	2,2177			(3,3,4,1,3,na)
Conveyor belt {GLO}| market for | Alloc Def, U	9,50989738886084E-8	m	Reg. normal	3,487			(5,4,4,2,1,na)
Gravel/sand quarry infrastructure {GLO}| market for | Alloc Def, U	4,74994874837949E-11	p	Reg. normal	3,0922			(1,3,4,1,1,na)
Synthetic rubber {GLO}| market for | Alloc Def, U	1,99997842037031E-6	kg	Reg. normal	1,2118			(2,3,4,2,1,na)
Tap water, at user {CH}| market for | Alloc Def, U	0,0100998910228701	kg	Reg. normal	1,2118			(2,3,4,2,1,na)
Steel, low-alloyed, hot rolled {GLO}| market for | Alloc Def, U	1,2999859732407E-5	kg	Reg. normal	1,2118			(2,3,4,2,1,na)
Lubricating oil {GLO}| market for | Alloc Def, U	1,84998003884254E-6	kg	Reg. normal	1,2118			(2,3,4,2,1,na)

Entradas conocidas desde la tecnósfera (electricidad/calor)

Nombre	Cantidad	Ud.	Distribución	DS^2 or 2*DS	Mín	Máx	Comentario
Electricity, medium voltage {CH}| market for | Alloc Def, U	0,00271997065170363	kWh	Reg. normal	1,2115			(2,3,4,1,1,na)
Diesel, burned in building machine {GLO}| market for | Alloc Def, U	0,0146998413897218	MJ	Reg. normal	1,2118			(2,3,4,2,1,na)
Heat, central or small-scale, other than natural gas {CH}| market for | Alloc Def, U	0,00243997367285178	MJ	Reg. normal	1,2115			(2,3,4,1,1,na)

Salidas

Figura 26: Captura de pantalla entrada de dades SimaPro

Font: Pròpia

"Sortides conegudes a la tecnosfera. Productes i co-productes":

En aquesta entrada d'informació hem d'identificar el material a estudi, en aquest cas Grava (les dades mostrades en la Figura 26 són dades extretes de la base de dades Ecoinvent), la seva unitat funcional i l'assignació de les emissions que es repercutirà a aquest producte. Si el procés generés més d'un producte o co-producte, el percentatge d'assignació ens indicarà què producte és el que es portarà el pes de les emissions o si aquestes es comparteixen equitativament entre els productes.

"Sortides conegudes a la tecnosfera. Productes evitats":

No és una entrada rellevant ja que solament se sol utilitzar quan analitzem processos de deposició i final de vida. En aquest projecte, com s'ha explicat anteriorment, ens concentrem en la fase de producte (A1-A3) per poder crear la base de la resta del cicle de vida.

“Entrades conegudes de la naturalesa (recursos)”:

En aquesta entrada estan els recursos que provenen de la naturalesa, en el cas de la grava:

- Transformation, to water bodies, artificial
- Water, unspecified natural origin, CH
- Occupation, water bodies artificial
- Occupation, mineral extraction site
- Gravel
- Transformation, from unknown

Aquestes entrades tenen en compte la modificació que es farà en el terreny, l’aigua, l’extracció, i un procés de transformació, que és genèric, per això posa unknown. Ens ho trobarem sovint que en el SimaPro hi ha processos o maquines genèriques perquè no poden avaluar totes les maquines del món o tots els processos que hi ha. Aquestes dades són de la base de dades Ecoinvent, i com no tenim informació específica del nostre país les donem per bones. No tots els materials de la construcció precisen d'aquest anterior apartat, però si que hi haurà materials que pengin d'ells que continguin aquesta informació.

“Entrades conegudes des de la tecnosfera (materials/combustibles)”:

En aquesta entrada s’inclou els materials i estructures necessàries per a la fabricació d’un material, acostuma haver-hi els combustibles com el consum de dièsel etc. En el cas de la grava computen les següents entrades:

- Industrial Machine, heavy, unspecified {GLO} market
- Municipal sòlid waste {GLO} market
- Building, hall, steel construction {GLO} market
- Waste mineral oil {GLO} market
- Recultivation, limestone mine {GLO} market
- Conveyor belt {GLO} market
- Synthetic rubber {GLO} market
- Tap water, at user {CH} market
- Steel. Low-alloyed, hot rolled {GLO} market
- Lubrification oil {GLO} market

Doncs com es pot comprovar inclou una maquina pesant (sense especificar), el oli per lubrificar-la, un transportador (conveyor), pel desgast de la maquinaria inclou goma sintètica etc.

“Entrades conegudes des de la tecnosfera (electricitat/calor)”

Aquesta entrada és molt similar a l’anterior però inclou la energia necessària per fer funcionar la cadena de producció.

- Electricity, mèdium voltatge {CH} market
- Diesel, burnet in Building Machine {GLO} market
- Heat, central or small-scale, other than natural gas {CH} market

En aquí hi ha electricitat, calor no produïda per gas natural i dièsel, en aquest cas introduït com a energia, no consum en kg o litres. El dièsel com a energia, s’ha de buscar el procés calorífic generat per la combustió de l'aquest en la base de dades de Ecoinvent.

La informació introduïda ha de ser revisada cada cert temps. En el cas de les dades més genèriques, segons normativa, haurà de revisar-se cada 10 anys. Aquesta informació se sol actualitzar quan les noves versions de les bases de dades són introduïdes. D'altra banda, les dades que han requerit una recerca del mercat local, és a dir les dades més específiques hauran de ser revisats cada 5 anys.

Tot aquest procés, més el llançament de les seves simulacions i la posterior verificació s’ha realitzat pels 154 materials, els quals han estat els següents:

Materials primaris del BEDEC (ITeC)	
ABS	granulat carborúndum
oli sintètic	gres esmaltat
acer al carbó	gres extruït
acer cadmiat	gres extruït esmaltat
acer conformat	gres porcellànic
acer conformat galvanitzat	gres premsat esmaltat
acer cromat	ferro colat esmaltat
acer esmaltat	formigó cel·lular prefabricat
acer galvanitzat	formigó polímer
acer inoxidable	formigó prefabricat
acer lacat	imprimació antioxidant
acer laminat	llana
acer laminat galvanitzat	llana de roca
acer negre	llana de vidre
acer pintat al forn	làtex
acer pre-lacat	llautó
acer recuit	llautó cromat
adhesiu copolímer acrílic	llautó esmaltat
adhesiu de cautxú sintètic	fusta
adhesiu de poliuretà	massilla acrílica
adhesiu de PVC	massilla de polisulfurs
adhesiu de resines epoxi	massilla de poliuretà
adhesiu en dissolució aquosa	massilla de silicona
adhesiu en dissolució alcohol	màstic
addició	metacrilat
additiu	morter prefabricat
additiu escumant	morter prefabricat
aglomerat de fusta	morter prefabricat alleugerit
aigua	morter prefabricat esmaltat
quitrà	morter prefabricat polit
alumini	morter prefabricat silicocalcari
alumini anoditzat	neoprè niló
alumini lacat	Oxi-asfalt
argila expandida	paper
argila expandida	perlita expandida
àrid reciclat	pedra natural
asfalt baquelita bentonita	pintura al forn
vernís	pintura al silicat
betum asfàltic	pintura antioxidant
betum asfàltic baixa temperatura	pintura asfàltica
bronze butil	pintura plàstica
calç	plom poliamida
cautxú asfàltic	polibutilè

cautxú reciclat	policarbonat
Cautxú sintètic	polièster
ciment	polièster reforçat
ciment ràpid	poliestirè
ceràmica	poliestirè extruït
ceràmica alleugerida	polietilè
ceràmica esmaltada	polietilè expandit
ceràmica refractària	polímer orgànic
ceràmica vidriada	polipropilè
coure	polisulfur poliuretà
coure recuit	pols quars
coure semidur	pols marbre
cua	pols seca polivalent
cola natural	porcellana
suro aglomerat	PVC
detergent	resina epoxi
diòxid de carboni	resina sintètica
dissolvent elèctrica	silicona
EPDM escuma alveolar	sulfat de magnesi
esmalt de poliuretà	tauler aglomerat
esmalt sintètic	tauler de partícules de fusta
mirall de lluna	tauler de partícules fusta xapada
escuma de polietilè	terratzo
escuma de poliuretà	terratzo neteja àcida
escuma elastomèrica	vermiculita expandida
fibra de poliamida	vidre
fibra mineral	vidre cel·lular
fibra natural	vidre reflector
fibra sintètica	vidre temperat
fibrociment NT	vidre vitroceràmic
fosa	vinil
gasoil	guix
goma elastomèrica	guix laminat
goma termoplàstica	zinc

Taula 3: Materials Primaris BEDEC

Font: BEDEC propietats, ITeC, Barcelona (ES)

3.4 Mixt elèctric i mixt de transport

Que implica?

L'elaboració del nostre projecte té com a finalitat portar les característiques dels materials en la base de dades Ecoinvent el més pròxim possible a la nostre tecnologia estatal.

Per a poder realitzar aquesta tasca, cal personalitzar les dades que obtenim d'Ecoinvent mitjançant el software SimaPro.

Un dels elements més diferenciadors entre països a part de la tecnologia pròpia que pugui tenir cadascú és el mixt elèctric i el mixt de transport.

Això significa que encara que un altre país produís un material/producte amb la mateixa tecnologia que nosaltres i els mateixos percentatges de materials que el formessin, els impactes mediambientals podrien variar significativament l'un respecte de l'altre. Doncs tota l'energia elèctrica utilitzada en els processos per a la seva elaboració podrien provenir d'energies no renovables en canvi l'altre país podria tenir una infraestructura estatal de producció elèctrica totalment neta.

El mixt de transport diferència de la mateixa manera els impactes mediambientals que se li computen en el cicle de vida a un material, doncs es molt important saber si el transport s'ha realitzat amb una tecnologia més o menys respectuosa amb el medi ambient.

Per a l'obtenció d'aquestes dades tant del mixt elèctric com del mixt de transports, és necessari posar-se en contacte amb els organismes reguladors estatals següents:

- **REE** (Xarxa Elèctrica d'Espanya).
- **OE** (Observatori de l'Energia).
- **ICAEN** (Institut Català d'Energia de la Generalitat de Catalunya).
- **OCC** (Oficina Catalana del Canvi Climàtic de la Generalitat de Catalunya).
- **OQA** (Oficina de Qualitat d'Aire de la Generalitat de Catalunya).

El mixt elèctric:

El mixt elèctric com el seu propi nom indica, és un mixt de totes les tecnologies a nivell estatal que participen en la producció d'un kWh d'energia elèctrica recollit en un endoll. Aquestes tecnologies es separen en dos grans grups, les que provenen de fonts renovables i les no renovables.

La REE (Red Eléctrica de España) publica anualment a any vençut un informe dels balanços de consum, demanda i producció de l'energia elèctrica estatal. Aquest informe ens mostra les diferents tecnologies i el percentatge de participació que tenen en la producció d'energia elèctrica a España.

Com que aquest informe es publica anualment, caldrà actualitzar el mixt elèctric periòdicament si es vol tenir una base de dades a nivell estatal acurada.

Energies renovables:

• **Hidràulica**: L'energia hidràulica és aquella que s'obté de l'aprofitament de les energies cinètica i potencial del corrent de l'aigua, salts d'aigua o marees. L'aigua es fa passar per una turbina hidràulica la qual transmet l'energia a un alternador el qual la converteix en energia elèctrica.

• **Mini-hidràulica**: Les centrals mini-hidràuliques són centrals hidroelèctriques a petita escala. Aquesta categoria també inclou la tecnologia hidroelèctrica reversible que consisteix a augmentar l'energia potencial de l'aigua pujant-la a un embassament o dipòsit mitjançant el consum d'energia elèctrica. Aquestes centrals estan concebudes per satisfer la demanda energètica en hores d'alta demanda i emmagatzemar energia en hores de baixa demanda.

Aquest tipus d'hidràulica s'ha hagut de remoure del càlcul de les energies renovables perquè segons la normativa, en utilitzar energia per pujar l'aigua, no la podem considerar com a tal.

• **Eòlica**: L'energia eòlica és l'energia obtinguda a partir de l'energia cinètica generada per l'efecte dels corrents d'aire. El vent fa girar uns aerogeneradors els quals produeixen electricitat i es distribueix mitjançant la connexió directa a la xarxa elèctrica.

• **Fotovoltaica**: L'energia solar o fotovoltaica és aquella que s'obté a partir de l'aprofitament de la radiació electromagnètica procedent del Sol. Els panells o mòduls fotovoltaics estan formats per un conjunt de cel·les (cèl·lules fotovoltaiques) que produeixen electricitat a partir de la llum que incideix en ells.

• **Solar tèrmica**: Una central tèrmica solar o termo-solar és una instal·lació que a partir de l'escalfament d'un fluid, generalment aigua, mitjançant radiació solar i el seu ús en un cicle termodinàmic, es produeix la potència necessària per moure un alternador per a generació d'energia elèctrica com una central tèrmica clàssica.

• **Biomassa**: L'energia tèrmica obtinguda mitjançant la combustió i/o piròlisis de la biomassa generarà calor que pot utilitzar-se per a calefacció, per a ús industrial com la generació de vapor o para, mitjançant un cicle termodinàmic convencional, moure un alternador i produir energia elèctrica.

Energies no renovables:

• **Nuclear**: L'energia nuclear s'obté mitjançant reaccions nuclears de combustible fissionable. Aquest procés produeix calor que al seu torn és emprat, a través d'un cicle termodinàmic convencional, per produir moviment en els alternadors que transformaran el treball mecànic en energia elèctrica.

• **Carbó / Fuel / Gas natural / Tèrmica no renovable**: L'energia procedent de residus municipals i/o recursos no renovables, com el carbó, el petroli o fuel i el gas natural, s'obté de l'aprofitament de la generació de calor de la combustió d'aquests combustibles. Aquesta calor és emprada en un cicle termodinàmic convencional per generar moviment en els alternadors que generaran energia elèctrica.

• **Cicle combinat**: L'energia obtinguda pel cicle combinat és generada per la coexistència de dos cicles termodinàmics en un mateix sistema, un que utilitza una turbina de vapor d'aigua i un altre que utilitza una turbina de gas natural mitjançant combustió. Ambdues turbines transformen el moviment dels alternadors en energia elèctrica.

RED ELÉCTRICA DE ESPAÑA

Martes, 31 diciembre 2013
Balance eléctrico diario (GWh)
Datos revisados el 31/01/2014 • 11:00:00

Balance eléctrico (GWh)	Día	Mes	%ΔMes	Año	%ΔAño	Año móvil (4)	%ΔMóvil
Hidráulica	89	2.302	-4,4	33.970	74,6	33.970	74,6
Nuclear	156	4.173	-8,5	56.827	-7,6	56.827	-7,6
Carbón nacional	0	2.118	0,1	13.669	-55,1	13.669	-55,1
Carbón importado	58	2.873	65,5	26.137	7,8	26.137	7,8
Carbón (1)	58	4.990	29,6	39.807	-27,3	39.807	-27,3
Fuel + Gas	0	0	-	0	-	0	-
Ciclo combinado	43	2.848	-1,3	25.074	-35,0	25.074	-35,0
Régimen ordinario	**346**	**14.313**	**4,4**	**155.679**	**-10,7**	**155.679**	**-10,7**
Consumos generación	-13	-635	10,1	-6.337	-19,7	-6.337	-19,7
Hidráulica	25	511	-17,6	7.097	52,8	7.097	52,8
Eólica (2)	210	4.943	-9,3	54.334	12,9	54.334	12,9
Solar fotovoltaica	9	413	9,5	7.900	0,9	7.900	0,9
Solar térmica	2	158	16,8	4.442	29,0	4.442	29,0
Térmica renovable	14	444	2,3	5.059	6,6	5.059	6,6
Térmica no renovable	82	2.667	-8,0	31.993	-4,5	31.993	-4,5
Régimen especial	**340**	**9.136**	**-7,9**	**110.823**	**8,3**	**110.823**	**8,3**
Generación neta	**673**	**22.814**	**-1,0**	**260.165**	**-3,2**	**260.165**	**-3,2**
Consumos en bombeo	-27	-581	6,4	-5.958	18,6	-5.958	18,6
Enlace Península-Baleares (6)	-3	-88	-3,6	-1.269	0,0	-1.269	0,0
Saldo intercambios internacionales	-2	-421	-61,0	-6.732	-39,9	-6.732	-39,9
Demanda transporte (b.c.)	**641**	**21.724**	**1,9**	**246.206**	**-2,2**	**246.206**	**-2,2**
Δdemanda corr. (3)	-	-	1,7	-	-2,2	-	-2,2
Pérdidas en transporte	-9	-314	0,6	-3.187	8,2	-3.187	8,2
Demanda distribución	**632**	**21.409**	**1,9**	**243.019**	**-2,4**	**243.019**	**-2,4**

(1) Clasificación de los grupos según sus consumos históricos de carbón. (2) Datos de telemedida y previsión para el día en curso.
(3) Corregidos los efectos de temperatura y laboralidad. (4) Año móvil: valor acumulado en los últimos 365 días ó 366 días en años bisiestos.
(6) Valor negativo: saldo exportador. Enlace Península - Baleares funcionando al mínimo técnico de seguridad hasta el 13-08-2012.

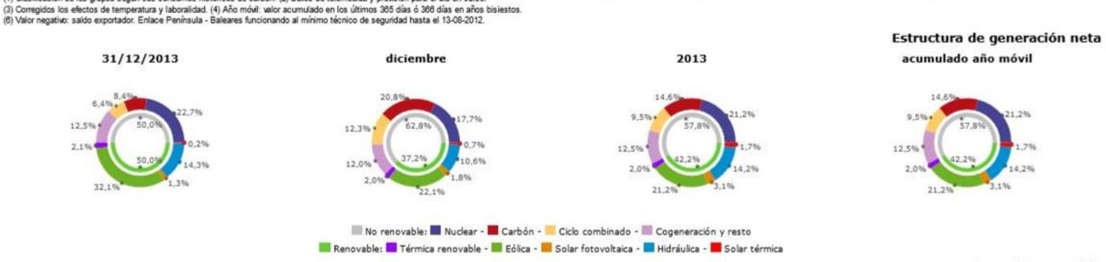


Figura 27: Red Eléctrica de España, Balance eléctrico anual del 2013
Font: Informe eléctrico diário (2013). Madrid (ES), http://www.ree.es.

Amb les dades que ens dona la Red elèctrica d'España, s'elabora el percentatge de participació de cada energia en la producció elèctrica, en altres paraules, el pes que té cada tecnologia en la producció d'electricitat a nivell estatal (Ceuta i Melilla no estan incloses).

Aquestes dades de caràcter general són incloses en el SimaPro a mode de mixt elèctric personalitzat, però caldrà contrastar-ho primer amb l'OE (observatori de l'energia) per obtenir el seu vistiplau.

MIX ELÈCTRIC (amb pèrdues)			**%**	**U.F.**
High voltage				
No renovable	56,34%	Nuclear	20,83%	kwh
		Carbó	14,59%	kwh
		Fuel	0,00%	kwh
		Gas natural	0,00%	kwh
		Cicle combinat	9,19%	kwh
		Tèrmica	11,73%	kwh
Renovable	41,34%	Hidràulica	12,45%	kwh
		Mini-hidràulica	2,60%	kwh
		Eòlica	19,91%	kwh
		Fotovoltaica	2,90%	kwh
		Solar tèrmica	1,63%	kwh
		Biomassa	1,85%	kwh
Pèrdues			2,32%	kwh
MIX			100,00%	kwh

Taula 4: Mixt elèctric

Font: Pròpia

La introducció d'aquestes dades en SimaPro no és definitiva ja que ens falta l'última verificació i una de les més importants en aquest sistema, que són els rendiments i eficiències de les tecnologies productores d'electricitat. Els organismes encarregats de proporcionar i/o validar les dades d'eficiències i rendiments, que influeixen directament a la producció en MJ, mega Joule, d'energia i el CO_2, diòxid de carboni, equivalent emès per les tecnologies, són ICAEN i OCC. Gràcies a aquesta col·laboració, s'ha pogut realitzar un mix energètic estatal amb uns indicadors ambientals fiables que ens proporcionaran unes dades finals més adequats als nostres recursos tecnològics.

El mixt de transport:

Crear un mixt de transport és una consideració especifica del projecte actual, ja que considerem que es un factor igual de diferencial que el mixt elèctric alhora de poder realitzar comparacions. També s'ha realitzat un mixt de turismes on s'inclouen turismes de benzina dièsel, híbrids, i elèctrics, amb les seves velocitats i normatives pertinents que ens generen tot un conjunt de variables per aplicacions futures, però no s'ha inclòs en aquest document perquè no és tant rellevant per a la realització d'aquest projecte.

El mixt de transport és el conjunt de vehicles en actiu. En el nostre cas, s'ha realitzat un estudi a nivell nacional, així que el parc de vehicles utilitzat analitza tots els vehicles de transport en aquest àmbit. Les organitzacions que ens van proporcionar aquestes dades són la OCC i la OQA.

Els vehicles tenen una normativa anomenada Euro, que canvia amb els anys, i determina la quantitat d'emissions que poden emetre en fase d'ús, per exemple entre 1994-1997 s'havia de complir amb la normativa Euro I.

L'objectiu és analitzar el parc de vehicles a nivell nacional per saber quants en tenim de cada normativa i així poder realitzar un mixt on es determini quin percentatge del parc nacional de vehicles forma part cada normativa.

Amb el mixt de transport s'obté un valor mig d'emissions per part del transport en el nostre país que s'utilitzarà en el SimaPro quan parlem de transports nacionals.

L'Oficina de Qualitat d'Aire i la seva publicació "Guia de càlcul d'emissions de contaminants a l'atmosfera" ens proporciona el nombre de vehicles actius, turismes, motocicletes, furgonetes, vehicles lleugers i vehicles pesats, diferenciats per tonatge, antiguitat i normativa vigent de la seva època de fabricació. Gràcies a aquestes dades, s'ha pogut obtenir un percentatge que relaciona l'antiguitat del vehicle amb la seva participació al parc de vehicles de transport pesat.

PARC DE VEHICLES PESATS 2013	%
Convencional (anterior 1994)	**7,57**
Euro I (1994-1997)	**4,59**
Euro II (1998-2000)	**25,57**
Euro III (2001-2005)	**38,26**
Euro IV (2006-2010)	**16,92**
Euro V (2010-2015)	**7,09**
Euro VI (Setembre del 2015)	**0,00**

Taula 5: Mixt de transport

Font: Pròpia

L'Oficina del Canvi Climàtic publica les seves dades en la “Guia pràctica per al càlcul d'emissions de gasos amb efecte d'hivernacle (GEH)” validades i contrastades per la Generalitat de Catalunya i que varien en funció del tonatge dels vehicles i la velocitat a la qual circulen. Aquestes taules ens proporcionen dades del diòxid de carboni emès en cada cas. A més, en aquesta guia, es relaciona mitjançant factors de conversió el consum del vehicle amb les seves emissions i el seu combustible.

En el software SimaPro, el transport es contempla com a un producte, i per tant no només és important el seu consum, sinó el manteniment, la fabricació i el ús del vehicle.

La informació d'ús l’hem extreta de les dades de la “Guia de càlcul d'emissions de contaminants a l'atmosfera” de la OQA. Aquesta guia conté en els seus annexos una taula amb totes les emissions (gasos d'efecte hivernacle, partícules volàtils flotants...) diferenciades de la mateixa manera que els vehicles pesats, per tonatge, antiguitat i normativa vigent de la seva època de fabricació.

En quant a fabricació i manteniment la base de dades d’Ecoinvent ja té uns camions predefinits per tonatge, els quals tenen assignats un valor de fabricació i de manteniment, aquest valors no cal canviar-los doncs nosaltres ens em centrat en personalitzar les dades d’aquests per tonatge, velocitat, antiguitat i normativa vigent per poder fer un anàlisis més fiable de la situació del nostre parc de transport.

3.5 Mètodes de càlculs

Per realitzar l'elecció del mètode de càlcul, hem de definir quins indicadors ambientals volem escollir, ja que cada mètode de càlcul dóna resposta a diferents indicadors ambientals.

En el cas d'aquest projecte, ens hem posat en contacte amb l'associació GBCe (Green Buildind Council Espanya) que és l'encarregada de proporcionar la certificació denominada VERDA, amb DGNB (German Sustainable Building Council) i hem afegit aquells indicadors ambientals que ja incloïa el banc de dades BEDEC i els indicadors presents en les DAP que s'han analitzat.

Així doncs, els indicadors escollits són els següents:

- **Potencial d'Escalfament Global, GWP / Global Warming Potencial**:
  Contribució total d'escalfament global resultant de l'emissió d'una unitat de gas a l'atmosfera pel que fa a una unitat de gas de referència, que és el diòxid de carboni, al que s'assigna un valor d'1. En el nostre cas s'ha tingut en compte escalfament global potencial a 100 anys vista (GWP100a). S'expressa en quilograms de diòxid de carboni, CO2, equivalents per unitat funcional declarada. *[Kg CO2 eq].*

- **Esgotament de la Capa d'Ozó, ODP / Ozone Depletion Potencial**:
  Destrucció de la capa d'ozó estratosfèric que protegeix a la terra dels rajos ultraviolats. Aquest procés de destrucció de l'ozó es deu a la ruptura de certs compostos que contenen clor i brom (clorofluorocarburs) quan aquests arriben a l'estratosfera, causant la ruptura catalítica de les molècules d'ozó. S'expressa en quilograms de compost clorofluorcarbonoso-11, o CFC-11, equivalent per unitat funcional declarada. *[Kg CFC11 eq].*

- **Potencial d'Acidificació del sòl i de l'aigua, AP / Acidification Potencial**:
  La pluja àcida té impactes negatius en els ecosistemes naturals i el medi ambient. Les principals fonts d'emissions de substàncies acidificants són l'agricultura i combustió de combustibles sòlids utilitzats per la producció d'electricitat, calefacció i transport. S'expressa en quilograms de diòxid de sofre, SOTA2, equivalents per unitat funcional declarada. *[Kg SO_2 eq].*

- **Potencial d'Eutrofització, EP / Eutrophication Potencial**:
  Efectes biològics adversos derivats de l'excessiu enriquiment amb nutrients de les aigües i les superfícies continentals. S'expressa en quilograms de fosfat, PO4, equivalents per unitat funcional declarada. *[Kg PO_4 eq].*

- **Potencial de Formació d'Ozó Troposfèric, POPC / Photochemical Oxidation**: Reaccions químiques ocasionades per l'energia de la llum del sol. La reacció d'òxids de nitrogen amb hidrocarburs en presència de llum solar per formar ozó és un exemple de reacció fotoquímica. S'expressa en quilograms de età equivalents per unitat funcional declarada. *[Kg ethene eq].*

- **Potencial d'Esgotament de Recursos Abiòtics per a Recursos Fòssils, ADP / Abiotic Depletion Potencial**:
Consum de recursos no renovables amb la següent reducció de disponibilitat per a les generacions futures. S'expressa en quilograms d'antimoni, Sb, equivalents per unitat funcional declarada. *[Kg Sb eq].*

- **Potencial de Toxicitat Humana, HTP / Human Toxicity Potencial**:
Representen els riscos en la salut per toxicitat. Aquestes substàncies, com a metalls pesats, es concentren en l'aire i en l'aigua. S'expressa en quilograms d'1,4 diclorobenzè, 1,4-DB, equivalents per unitat funcional declarada. *[Kg 1,4-DB eq].*

- **Producció de Càncer i altres Problemes de Salut / Respiratory organics**:
Representen els riscos en la salut per inhalació de partícules orgàniques suspeses en l'aire. S'expressa en quilograms d'etilè, C2H4, equivalents per unitat funcional declarada. *[Kg C_2H_4 eq].*

- **Compostos Volàtils Orgànics diferents del Metà, NMVOC / Senar-Methane Volatile Organic Compounds**:
Compostos formats principalment per hidrocarburs als quals se'ls uneix algun dels següents grups: alcohols, aldehids, alcans, aromàtics, cetones i derivats halogenats. Es caracteritzen per ser substàncies fàcilment vaporitzables a temperatura ambienti, i moltes són incolores i inodores. S'expressa en quilograms de NMVOC equivalents per unitat funcional declarada. *[Kg NMVOC eq].*

- **Material Particulat Respirable, PM2,5 / Respiratory inorganics**:
Representen els riscos en la salut per inhalació del material particulat respirable present en l'atmosfera de les ciutats en forma sòlida o líquida com a pols, cendres, sutge, partícules metàl·liques i ciment entre unes altres. Estan constituïdes per aquelles partícules de diàmetre aerodinàmic inferior o igual als 2,5 micròmetres.

S'expressa en quilograms de material particulat respirable, PM2.5, equivalents per unitat funcional declarada.
[Kg PM2,5 eq].

- **Formació de Material Particulat, PM10 / Particulate Matter Formation**:
  Material en forma de partícules suspès en l'atmosfera de les ciutats en forma sòlida o líquida com a pols, cendres, sutge, partícules metàl·liques i ciment entre unes altres. Estan constituïdes per aquelles partícules de diàmetre aerodinàmic inferior o igual als 10 micròmetres. Estan formades principalment per compostos inorgànics com a silicats i aluminats, metalls pesats entre uns altres, i material orgànic associat a partícules de carboni. S'expressa en quilograms de material en partícules, PM10, equivalents per unitat funcional declarada. *[Kg PM10 eq].*

- **Esgotament d'Aigua, WD / Water Depletion**:
  Aigua natural en la superfície de la Terra, en les capes de gel, en els casquets de gel, glaceres, icebergs, pantans, llacunes, llacs, rius i rierols, i aigües subterrànies d'aqüífers i corrents subterranis. Generalment es caracteritza per tenir baixes concentracions de sals dissoltes i d'altres sòlids totals dissolts. El terme exclou específicament aigua de mar i aigua salobre encara que inclou aigües riques en minerals, com a aigües termals. El terme "aigua corrent" s'utilitza per descriure aigua dolça en contrast amb aigua salada. El seu valor es dóna en unitats de metres cúbics, m3, utilitzats per unitat funcional declarada. *[m^3].*

- **Ús de recursos d'Energia Primària no Renovable / Senar renewable energy**:
  Energia no renovable és aquella procedent de fonts no definides com a fonts d'energia no renovable. Recurs no renovable és aquell que existeix en una quantitat limitada i que no es reposa en una escala temporal humana. El seu valor es dóna en unitats de mega Joule, MJ, consumits per unitat funcional declarada. *[MJ].*

- **Ús de recursos d'Energia Primària Renovable / Renewable energy**:
  Energia renovable és aquella procedent de fonts no fòssils. Exemples: eòlica, solar, geotèrmica, oceànica, hidroelèctrica, biomassa, gasos d'abocador, gasos de plantes de depuració, biogàs, etc. Recurs renovable és aquell que creix, es reposa o depura de forma natural en una escala temporal humana. Un recurs renovable podria esgotar-se, però pot durar indefinidament si s'administra correctament. El seu valor es dóna en unitats de mega Joule, MJ, consumits per unitat funcional declarada. *[MJ].*

- **Residus perillosos abocaments / Hazardous waste**:
  Els residus perillosos representen una amenaça substancial o potencial per a la salut o el medi ambient. Són aquells residus que s'inclouen en la llista europea de residus perillosos. S'expressa en quilograms de residu produïts per unitat funcional declarada. *[Kg].*

- **Residus no perillosos abocaments / Senar hazardous waste**:
  Són aquells residus que no s'inclouen en la llista europea de residus perillosos. S'expressa en quilograms de residu produïts per unitat funcional declarada. *[Kg].*

- **Residus radioactius abocaments / Radioactive waste**:
  Els residus radioactius són residus que contenen material compost d'elements que emeten radioactivitat. Són el subproducte de diversos processos nuclears que tenen lloc en les centrals per obtenir l'energia que utilitzem. Els abocaments radioactius són obtinguts de la generació d'energia nuclear i altres aplicacions de l'energia nuclear i altres aplicacions de la fissió nuclear i la tecnologia nuclear. Els residus radioactius són perillosos per a la majoria de les formes de vida i el medi ambient i estan regulats per les agències governamentals amb la finalitat de protegir la salut humana i el medi ambient. S'expressen en quilograms de residu produïts per unitat funcional declarada. *[Kg].*

Segons la normativa vigent a Espanya, els valors mínims a escollir són els referenciats en el mètode CML-IA de la Universitat de Leiden (Països Baixos). Els factors de caracterització d'aquest mètode de càlcul són anomenats de "referència" segons la UNE-EN ISO 15804.

L'objectiu de la base de dades, és crear en les empreses la necessitat d'intentar complementar els resultats generalistes obtinguts, els quals els seran atribuïts, i així proporcionar dades més precises que aniran substituint les nostres dades amb la finalitat de crear dades verídiques mediambientals del nostre sector. Així doncs, s'ha mantingut el CML-IA com a base i s'ha tingut en compte altres mètodes de càlcul, per tal d'obtenir uns indicadors ambientals amb uns valors (que no puc comentar per la clàusula de confidencialitat de l'ITeC), que incentivin a les empreses del sector la seva participació.

Les dades genèriques no desapareixeran mai, perquè són necessàries ja que sempre existiran partides d'obra genèriques on no hi ha fabricants que incorporin informació, per exemple un pilar de formigó armat.

En la figura 28 que es mostra a continuació podem veure els diferents mètodes de càlcul que hi ha només dins la pestanya “European”. Aquests mètodes s'han comparat entre ells per crear un “nou” mètode de càlcul personalitzat per a aquest projecte que porta el nom de mètode de càlcul ITeC però són totalment confidencials.

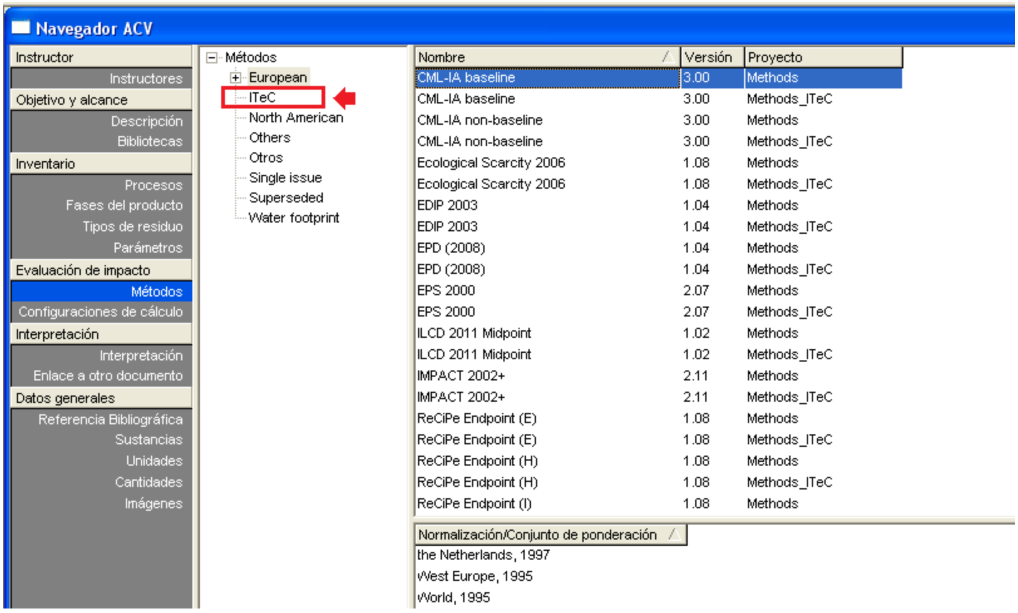


Figura 28: Mètodes de càlcul SimaPro

Font: Pròpia

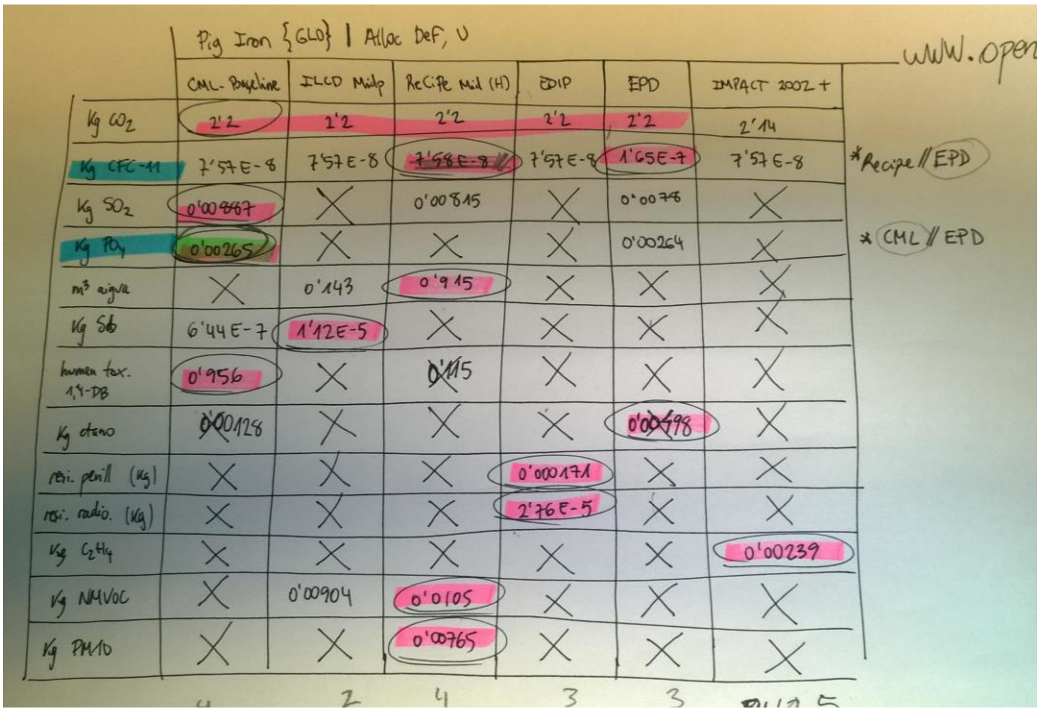


Figura 29: Mètodes de càlcul escollits SimaPro

Font: Pròpia

U.F.		Kg
Non renewable energy (fossil)	Energy (MJ)	2,36
Non renewable energy (nuclear)	Energy (MJ)	0,151
Non renewable energy (biomass)	Energy (MJ)	0,00135
Renewable energy (biomass)	Energy (MJ)	0,00271
Renewable energy (wind, solar, geothe.)	Energy (MJ)	0,0357
Renewable energy (water)	Energy (MJ)	0,022
Global warming (GWP100a)	Kg CO2 eq.	0,237
Human toxicity	Kg 1,4-DB eq.	0,0628
Acidification	Kg SO_2 eq.	0,000607
Eutrophication	Kg PO_4 eq.	0,000144
Radioactive waste	Kg	8,00E-006
Hazardous waste	Kg	2,53E-006
Ozone depletion	Kg CFC11 eq.	2,03E-008
Water depletion	m^3 aigua	0,289
Respiratory inorganics	Kg PM2,5 eq.	0,00013
Particulate matter formation	Kg PM10 eq.	0,000226
Respiratory organics	Kg C_2H_4 eq.	1,04E-004
Mineral, fossil & ren resource	Kg Sb eq.	6,65E-006
Photochemical oxidant formation	Kg NMVOC eq.	0,000708
Photochemical oxidation	Kg ethene eq.	0,000193

Taula 6: Sortida de dades de la Ceràmica

Font: Pròpia

4. CONCLUSIONS:

Aquest últim any ha sigut una experiència inoblidable. Poder realitzar aquest treball final de grau en una institució com l'ITeC ha sigut una experiència molt enriquidora, tant en el camp professional com en el camp personal.

He pogut aprendre molt en el tema de la sostenibilitat, pràcticament des de cero, ja que a la universitat pràcticament no se'ns parla d'aquest tema, i aquest desconeixement també és pot aplicar en molts estrats del sector que no ens han facilitat les dades perquè ni tan sols contemplaven aquesta visió sobre la sostenibilitat.

També cal dir que el nom de l'ITeC ens ha facilitat molt les coses alhora de posar-nos en contacte amb organismes oficials inclús fora del territori nacional, per tal de recaptar i verificar els mètodes emprats.

Ha sigut una gran experiència poder haver format part de reunions d'empresa, assistir a conferències on es parlava de la sostenibilitat i el BIM i realitzar reunions amb departaments tècnics de la Generalitat de Catalunya i veure com al presentar-los el projecte el consideraven com un treball molt innovador, inclús es prestaven a ajudar-nos tant com fos possible.

En general ha sigut una experiència molt completa, en la que he aprés més del que em pensava d'un tema que ha resultat ser més interessant i amb vistes a futur molt més important del que m'esperava.

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6. AGRAÏMENTS:

M’agradaria agrair, en primer lloc al professor i tutor d’aquest projecte Licinio Alfaro, per haver-me donat la oportunitat de treballar durant un any en el ITeC, i per haver-me ensenyat a fer certificacions energètiques ben fetes.

També agrair al ITeC que ens hagi format en tots els seus programes junt amb un títol que ho acrediti sense tenir l’obligació de fer-ho.

Evidentment agrair a tots els familiars i amics que m’han donat suport, també al meu company de feina Jose Lucas, sense el qual el projecte no s’hagués pogut realitzar, i per últim a la meva àvia que va passar a millor vida durant la redacció d’aquest treball final de grau.

7. ANNEXES:

DECLARACIÓN AMBIENTAL DE PRODUCTO

DAPc®.002.010

DE ACUERDO CON LAS NORMAS
ISO 14.025 e ISO 21.930

PRODUCTO

Gres porcelánico medio

EMPRESA

GRESPANIA CERAMICA

DESCRIPCIÓN DEL PRODUCTO

El producto incluye diversos formatos de gres porcelánico (BIa).

RCP DE REFERENCIA

RCP002 - Productos de revestimiento cerámico – V.1 (2010)

PLANTA PRODUCCIÓN

GRESPANIA, S.A.
CV-16 (Ctra. Castellón-Alcora)
Km. 2,200 P.O.Box 157
12080 Castellón - España

VALIDEZ

Desde: 16.09.2013
Hasta: 16.09.2018

La validez de DAPc® 002.010 está sujeta a las condiciones del reglamento DAPc®. La edición vigente de esta DAPc® es la que figura en el registro que mantiene CAATEEB; a título informativo, se incorpora en la página web del Sistema http://es.csostenible.net/dapc

Declaración Ambiental de Producto Gres porcelánico medio
Resumen ejecutivo

SISTEMA DAPc®

Declaraciones Ambientales de Producto en el sector de la Construcción
http://es.csostenible.net

ADMINISTRADOR DEL SISTEMA

Col·legi d'Aparelladors, Arquitectes Tècnics i Enginyers d'Edificació (CAATEEB)
C. Bon Pastor, 5, 08021 Barcelona
www.apabcn.cat

TITULAR DE LA DECLARACIÓN

GRESPANIA, S.A.; CV-16 (Ctra. Castellón-Alcora)
Km. 2,200 P.O.Box 157; 12080 Castellón - España

DECLARACIÓN REALIZADA POR:
ReMa-MEDIOAMBIENTE, S.L.
Calle Crevillente 1, entlo, 12005, Castellón - España

NÚMERO DE DECLARACIÓN	DAPc® 002.010
PRODUCTO DECLARADO	GRES PORCELÁNICO MEDIO

DESCRIPCIÓN DEL PRODUCTO

El producto incluye diferentes formatos de Gres porcelánico medio. Las variaciones en las entradas y salidas en ningún caso superan el 10 %.

FECHA DE REGISTRO	16.09.2013

VALIDEZ

Esta declaración verificada autoriza a su titular a llevar el logo del sistema de ecoetiquetado DAPc®. La declaración es aplicable exclusivamente al producto mencionado y durante cinco años a partir de la fecha de registro. La información contenida en esta declaración ha sido suministrada bajo responsabilidad de GRESPANIA.

FIRMA CAATEEB	FIRMA VERIFICADOR ACREDITADO
Sra. Rosa Remolà, presidenta del CAATEEB	Sr. Xavier Folch, auditor acreditado del ITeC
COL·LEGI D'APARELLADORS, ARQUITECTES TÈCNICS I ENGINYERS D'EDIFICACIÓ DE BARCELONA	ITeC Institut de Tecnologia de la Construcció de Catalunya XAVIER FOLCH

Esta declaración ambiental de producto cumple las normas ISO 14025 e ISO 21930 y describe información de carácter ambiental relativa al ciclo de vida del producto Gres porcelánico medio fabricado por GRESPANIA en su planta de Castellón. Esta declaración se basa en el documento *RCP 002 Productos de revestimiento cerámico - Versión 1 – 2010.06.11.*

Declaración Ambiental de GRES PORCELÁNICO MEDIO

1. Descripción del producto y de su uso

Las baldosas de gres porcelánico se clasifican en el grupo BIa (Baldosas cerámicas prensadas en seco con baja absorción de agua menor o igual al 0,5%), según la norma ISO 13006 y la UNE-EN 14411:2007.

Tabla 1. **Producto incluido y dimensiones del mismo.**

Producto	**Grupo**	**Acabados**	**Dimensiones (cmxcm)**
GRES PORCELÁNICO y PORCELÁNICO TÉCNICO	BIa	- Sin rectificar - Rectificado - Pulido - Sin pulir	14,5/19,5X120, 15X60, 15X80, 22X90, 30x30, 30x60, 40x80, 45x45, 45X90, 60x60, 60X120 y 80X80.

El principal uso recomendado para este producto es el revestimiento cerámico de suelos y paredes.

2. Descripción de las etapas de ciclo de vida

2.1. Fabricación (A1, A2 y A3)

Materias primas (A1 y A2)

El producto GRES PORCELÁNICO (BIa) está compuesto básicamente por arcilla, feldespato y arena con una capa de esmalte compuesta principalmente por feldespato, carbonato, silicatos y caolín entre otros.

Las materias primas utilizadas tienen orígenes diferentes (provincial, nacional, Turquía, Ucrania, Italia o Reino Unido). Esta variación es debida a la imposibilidad de obtener dichas materias primas de un mismo origen. Las materias primas procedentes de fuera de España son trasportadas con carguero hasta el puerto de Castellón, y de ahí en camión hasta la planta de fabricación del atomizado. Para los transportes por mar, se ha escogido un tipo de carguero transoceánico, cuya distancia de transporte difiere en cada caso dependiendo el origen. Las materias primas arcillosas se transportan a granel, es decir, que no requieren material de embalaje. Las fritas son transportadas en bigbags sobre palets.

Fabricación (A3)

El proceso industrial de la planta de GRESPANIA situada en Castellón se inicia con la recepción de arcilla atomizada, que se recibe en tolvas de construcción metálica, preparadas para el vertido de los camiones de transporte. Posteriormente, por mediación de una cinta de descarga y otra de transporte, se lleva la arcilla a los silos de reposo correspondientes.

Desde este punto y mediante un sistema de transporte la arcilla, que en caso necesario puede ser tratada o bien en una torre tecnológica, o un coloreador, con la finalidad de generar determinado tipo de efectos, es transportada hasta las prensas.

Las prensas son hidráulicas, con funcionamiento totalmente automático y controlado electrónicamente. La arcilla es introducida en los moldes mediante un carro alimentador, que retira previamente de ellos las piezas prensadas en la prensada anterior. Estas piezas pasan a una cinta recogedora, donde se conducen a los secaderos verticales, donde es eliminada la humedad residual de las mismas.

Los diferentes componentes de los esmaltes como son fritas, colores y aditivos, se cargan junto con el agua en molinos con carga molturante. Una vez molturado, el esmalte se deposita en cocios dotados de agitadores para evitar que precipiten sus diferentes componentes y de aquí se bombean o transportan a la línea de esmaltado.

La línea de esmaltado está dotada con elementos adecuados para el transporte de las piezas. Los diferentes esmaltes que componen cada modelo son aplicados aquí en forma de suspensión acuosa en cada uno de los dispositivos (discos, campanas, aerógrafos) situados a lo largo de la línea.

Una vez las piezas han sido esmaltadas y decoradas, se recogen con una máquina cargadora que las introduce en los boxes por estratos, para su almacenamiento en el parque, a la espera de entrar en los hornos.

Los hornos son de tipo monoestrato, en los que las baldosas avanzan por su interior en una sola capa que desliza sobre un lecho de rodillos rodantes resistente a altas temperaturas. Las piezas, una vez cocidas, se cargan en boxes y se llevan a la sección de selección

Antes de entrar en las líneas de selección es posible realizar un rectificado y/o pulido en la pieza. Esta sección de pulido, corte y rectificado de azulejos, permitirá procesar una fracción de la producción, con la finalidad de obtener piezas con un excepcional brillo superficial (caso de pulir), piezas más pequeñas a partir de otra de mayor tamaño (caso de cortar) y/o piezas con extraordinaria precisión dimensional, permitiendo además la eliminación del borde redondeado típico de los azulejos (caso de rectificar).

Existe a su vez una sección de corte, cuya finalidad es la obtención de formatos excepcionalmente pequeños a partir de piezas de mayor tamaño.

Una vez en las líneas de selección, ya sea habiendo pasado o sin pasar por la sección de rectificado y pulido, se descargan de nuevo las vagonetas y se pasan por un tapete donde se realiza una selección visual de las piezas, que son marcadas según calidades y separadas a las líneas de salida correspondiente. En la línea existe un plánar y un calibre que se ocupa de detectar la planaridad y ortogonalidad de las piezas. Finalmente existe un sistema de embalado automático y un sistema de paletizado robotizado.

Las piezas clasificadas se embalan en un envase de cartón. El número de piezas que se incluye en cada caja de cartón varía según el formato y peso de las piezas. Las diferentes cajas de cartón componen un palé de madera. Dichos palés son cubiertos por bolsas o filmes de LDPE retráctil o termorretráctil que se adapta a las dimensiones de los palés. Una vez conformado el palé, se almacena en la zona destinada a tal fin.

2.2. Construcción

Transporte del producto (A4)

No incluido dentro de los límites del sistema del estudio.

Proceso de instalación del producto y construcción (A5)

No incluido dentro de los límites del sistema del estudio.

2.3. Uso del producto

La etapa de uso se divide en los siguientes módulos:

- Uso (B1)
- Mantenimiento (B2)
- Reparación (B3)
- Substitución (B4)
- Rehabilitación (B5)
- Uso de la energía operacional (B6)
- Uso del agua operacional (B7)

No incluido dentro de los límites del sistema del estudio.

2.4. Fin de vida

La etapa de fin de vida incluye los siguientes módulos:

- Deconstrucción y derribo (C1)
- Transporte (C2)
- Gestión de residuos para reutilización, recuperación y reciclaje (C3)
- Eliminación final (C4)

No incluido dentro de los límites del sistema del estudio.

2.5. Módulo D: beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

En el módulo D se declara la existencia de créditos ambientales (es decir, impactos ambientales evitados) debido a la reutilización, recuperación o reciclaje de algunos de los flujos de salida del sistema. Se declararán los impactos netos resultantes de contabilizar los impactos de producción de los materiales o combustibles primarios, desplazados o sustituidos, menos las cargas ambientales de las operaciones de reutilización, recuperación y reciclaje.

Se han considerado que se evitan cargas en:

- la gestión de los residuos de envases y embalajes generados en la etapa de fabricación,
- la energía eléctrica generada en la atomización vendida a la red eléctrica. En el Módulo A1 se han contabilizado los impactos ambientales generados por la combustión de gas natural del proceso de atomización, energía térmica utilizada para el secado del atomizado y la generación eléctrica de la cogeneración. Parte de esa electricidad se autoconsume en las instalaciones del atomizador y parte es vendida a la red eléctrica. Los beneficios ambientales generados por la energía desplazada es cuantificada en este Módulo D.

3. Análisis de Ciclo de Vida

El análisis del ciclo de vida en el que se basa esta declaración se ha realizado siguiendo las normas ISO 14040 e ISO 14044 y el documento RCP 002 Productos de revestimiento cerámico Versión 1 – 2010.06.11.

Este ACV es del tipo "de la cuna a la puerta de la fábrica", es decir, que abarca la etapa de fabricación del producto, dejando fuera las etapas de construcción, uso y fin de vida.

Se han utilizado datos específicos de la planta de Castellón correspondientes al año 2012 para inventariar la etapa de fabricación.

3.1. Unidad funcional

La unidad declarada es *"1 m^2 de **GRES PORCELÁNICO MEDIO**"*

3.2. Límites del sistema

Figura 1: **Límites del sistema**

3.3. Indicadores de la evaluación de impactos

Tabla 4. **Indicadores de la evaluación de impacto**

Parámetro evaluado	**Unidad por m² de panel**	**Etapa del ciclo de vida**													
		Fabricación	**Construcción**		**Uso**							**Fin de vida**			
		A1. – A3.	**A4.**	**A5.**	**B1.**	**B2.**	**B3.**	**B4.**	**B5.**	**B6.**	**B7.**	**C1.**	**C2.**	**C3.**	**C4.**
Potencial de Calentamiento Global	kg de CO_2 eq.	*1,26E+01*	-	-	-	-	-	-	-	-	-	-	-	-	-
Potencial de Agotamiento de Ozono Estratosférico	Kg de CFC11 eq.	*1,44E-07*	-	-	-	-	-	-	-	-	-	-	-	-	-
Potencial de Acidificación	Kg de SO_2 eq.	*3,33E-02*	-	-	-	-	-	-	-	-	-	-	-	-	-
Potencial de Eutrofización	Kg de PO_4^- eq.	*5,86E-03*	-	-	-	-	-	-	-	-	-	-	-	-	-
Potencial de Agotamiento de Recursos Abióticos (elementos)	Kg de Sb eq.	*1,02E-01*	-	-	-	-	-	-	-	-	-	-	-	-	-
Potencial de Formación de Ozono Fotoquímico	kg de etano eq.	*1,18E-03*	-	-	-	-	-	-	-	-	-	-	-	-	-
Potencial de Agotamiento de Recursos Abióticos (recursos fósiles)	MJ	*2,12E+02*	-	-	-	-	-	-	-	-	-	-	-	-	-

A1. Suministro de materias primas
A2. Transporte
A3 Fabricación (según figura 1)
A4. Transporte
A5. Procesos de instalación y construcción

B1. Uso
B2. Mantenimiento y transporte
B3. Reparación
B4. Substitución
B5. Rehabilitación
B6. Uso de la energía operacional

C1. Deconstrucción y derribo
C2. Transporte
C3. Gestión de residuos para reutilización, recuperación y reciclaje.
C4. Eliminación final

-: las RCP no prevén el cálculo de este impacto al no ser relevante para este tipo de producto.

3.4. Datos de inventario de ciclo de vida

Tabla 5. **Datos de inventario de ciclo de vida**

Parámetro evaluado	**Unidad por m² de panel**	**Etapa del ciclo de vida**													
		Fabricación	**Construcción**		**Uso**							**Fin de vida**			
		A1. – A3.	**A4.**	**A5.**	**B1.**	**B2.**	**B3.**	**B4.**	**B5.**	**B6.**	**B7.**	**C1.**	**C2.**	**C3.**	**C4.**
Consumo de energía primaria renovable	MJ (valor calorífico neto)	1,65E+01	-	-	-	-	-	-	-	-	-	-	-	-	-
Consumo de energía primaria no renovable	MJ (valor calorífico neto)	2,20E+02	-	-	-	-	-	-	-	-	-	-	-	-	-
Utilización de combustibles secundarios no renovables	MJ (valor calorífico neto)	0,00E+00	-	-	-	-	-	-	-	-	-	-	-	-	-
Utilización de combustibles secundarios renovables	MJ (valor calorífico neto)	0,00E+00	-	-	-	-	-	-	-	-	-	-	-	-	-
Consumo de agua dulce	m3	6,60E-02	-	-	-	-	-	-	-	-	-	-	-	-	-
Producción de residuos	kg	1,61E+00	-	-	-	-	-	-	-	-	-	-	-	-	-
Peligrosos	kg	3,99E-4	-	-	-	-	-	-	-	-	-	-	-	-	-
No peligrosos	kg	1,61E+00	-	-	-	-	-	-	-	-	-	-	-	-	-
Radioactivos	kg	1,85E-4	-	-	-	-	-	-	-	-	-	-	-	-	-
Material de salida para	kg	1,24E-2	-	-	-	-	-	-	-	-	-	-	-	-	-
Reutilización	kg	0,00E+00	-	-	-	-	-	-	-	-	-	-	-	-	-
Reciclaje	kg	1,24E-2	-	-	-	-	-	-	-	-	-	-	-	-	-
Valoración energética	kg	0,00E+00	-	-	-	-	-	-	-	-	-	-	-	-	-

A1. Suministro de materias primas
A2. Transporte
A3 Fabricación (según figura 1)
A4. Transporte
A5. Procesos de instalación y construcción

B1. Uso
B2. Mantenimiento y transporte
B3. Reparación
B4. Substitución
B5. Rehabilitación
B6. Uso de la energía operacional
B7. Uso del agua operacional

C1. Deconstrucción y derribo
C2. Transporte
C3. Gestión de residuos RCP no prevén el cálculo de este impacto para reutilización, recuperación y reciclaje.
C4. Eliminación final

-: *las*
al no ser relevante para este tipo de producto.

3.5. Beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

Anexo 1 - Tabla 4. **Indicadores de la evaluación de impacto**

Reutilización, recuperación y reciclaje		
Parámetro evaluado	**Unidad por m² de panel**	**D.**
Potencial de Calentamiento Global	kg de CO_2 eq.	-6,82E-01
Potencial de Agotamiento de Ozono Estratosférico	Kg de CFC11 eq	-5,40E-09
Potencial de Acidificación	Kg de SO_2 eq.	-3,41E-04
Potencial de Eutrofización	Kg de PO_4^{3-} eq.	-2,23E-04
Potencial de Agotamiento de Recursos Abióticos (elementos)	Kg de Sb eq.	-5,38E-03
Potencial de Formación de Ozono Fotoquímico	kg de etano eq.	-1,42E-05
Potencial de Agotamiento de Recursos Abióticos (recursos fósiles)		-1,11E+01

D. Beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

Anexo 1 - Tabla 5. **Datos de inventario de ciclo de vida**

Reutilización, recuperación y reciclaje		
Parámetro evaluado	**Unidad por m² de panel**	**D.**
Consumo de energía primaria renovable	MJ (valor calorífico neto)	-8,99E-01
Consumo de energía primaria no renovable	MJ (valor calorífico neto)	-1,49E+01
Utilización de combustibles secundarios no renovables	MJ (valor calorífico neto)	0,00E+00
Utilización de combustibles secundarios renovables	MJ (valor calorífico neto)	0,00E+00
Consumo de agua dulce	m³	-6,5E-03
Producción de residuos	kg	-7,17E-02
Peligrosos	kg	-2,61E-05
No peligrosos	kg	-7,10E-02
Radioactivos	kg	-7,14E-04
Material de salida para	kg	0,00E+00
Reutilización	kg	0,00E+00
Reciclaje	kg	0,00E+00
Valoración energética	kg	0,00E+00

D. Beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

3.6. Recomendaciones de esta DAPc®

La comparación de productos de la construcción se debe hacer aplicando la misma unidad funcional y a nivel de edificio, es decir, incluyendo el comportamiento del producto a lo largo de todo su ciclo de vida.

Las declaraciones ambientales de producto de diferentes sistemas de ecoetiquetado tipo III no son directamente comparables, puesto que las reglas de cálculo pueden ser diferentes.

La presente declaración representa el comportamiento medio del producto gres porcelánico fabricado por GRESPANIA.

3.7. Reglas de corte

Se ha incluido más del 95% de todas las entradas y salidas de masa y energía del sistema, quedando fuera:

• Emisiones difusas de partículas a la atmósfera generadas durante el transporte y almacenamiento de materias primas de naturaleza pulverulenta.
• Contaminantes atmosféricos canalizados, generados en las etapas de combustión (secado por atomización, secado de piezas y cocción) no contemplados por la legislación aplicable.
• El proceso de reciclaje y reutilización de los residuos generados a lo largo del ciclo de vida de los recubrimientos cerámicos debido al método de asignación de cargas aplicado.
• La producción de maquinaria y equipamiento industrial debido a la dificultad que supone inventariar todos los bienes implicados, y también porque la comunidad de ACV considera que el impacto ambiental por unidad de producto es bajo en relación al resto de procesos que sí se incluyen. Además, las bases de datos utilizadas no incluyen estos procesos así que su inclusión requeriría un esfuerzo adicional fuera del alcance del estudio.

3.8. Otros datos

Los residuos de la industria cerámica están incluidos como "residuos no peligrosos" en la lista europea de residuos con código CER 101200: "Residuos de la fabricación de productos cerámicos" y CER 101299 "Residuos no especificados en otra categoría" (Decisión 2000/532/CE).

4. Información técnica y escenarios

Fuera de los límites del sistema.

5. Información adicional

Características técnicas del producto	- Marcado CE - Euroclase de reacción al fuego : $A1_{FL}$ / A1 - Resistencia Fuerza de rotura > 1.300 N - Absorción al agua Grupo BIa ≤ 0,5% - Resistencia a flexión (N/mm2) >50 - Resistencia al choque térmico: resiste - Resistencia al cuarteo: resiste - Resistencia a las heladas: resiste

- Certificado por la implementación de un Sistema de Calidad que cumple los requerimientos de la ISO 14001:2004.
- Certificado por la implementación de un Sistema de Calidad que cumple los requerimientos de la ISO 9001:2008.
- Declaración de Prestaciones del Marcado CE

6. RCP y verificación

Esta declaración se basa en el Documento *RCP 002 Productos de revestimiento cerámico V.1.*

La revisión de la *RCP 002- Productos de revestimiento cerámico V.1.* fue realizada por el Consejo asesor del sistema DAPc®.
Verificación independiente de la declaración y de los datos, de acuerdo con la norma ISO 14025:2006 ☐ interna ☒ externa
Verificador de tercera parte: - Xavier Folch Berenguer, ITeC Verificació VEDAP-001-10
Fecha de la verificación : 13 septiembre 2013

Referencias

- Análisis de Ciclo de Vida de GRES PORCELÁNICO. ReMa-MEDIOAMBIENTE, S.L. para GRESPANIA 2013 (no publicado)

ADMINISTRADOR DEL SISTEMA

Col·legi d'Aparelladors, Arquitectes Tècnics i Enginyers d'Edificació de Barcelona (CAATEEB)

Bon Pastor 5, 08021 Barcelona

www.apabcn.cat

EMAS
GESTIÓ AMBIENTAL VERIFICADA
REG. No. 000142

UNE-EN-ISO 14001
DNV
EMPRESA CERTIFICADA

DECLARACIÓN AMBIENTAL DE PRODUCTO

DAPc.001.001

DE ACUERDO CON LAS NORMAS
ISO 14.025 e ISO 21.930

PRODUCTO

ECO 50 D

EMPRESA

ISOVER

DESCRIPCIÓN DEL PRODUCTO

El producto ECO 50 D es un panel compacto de lana de vidrio no hidrófila, sin revestimiento, de 50 mm de espesor, 1350 mm de longitud, 600 mm de ancho y 18 kg/m^3 de densidad.

RCP DE REFERENCIA

RCP001 – Productos aislantes térmicos – V.1 (2010)

PLANTA PRODUCCIÓN

Saint-Gobain Cristalería, S.A
División Aislamiento-ISOVER
Azuqueca de Henares, 19200
Guadalajara

VALIDEZ

Desde: 28.10.2010
Hasta: 28.10.2015

La validez de DAPc 001.001 está sujeta a las condiciones del reglamento DAPc. La edición vigente de esta DAPc es la que figura en el registro que mantiene CAATEEB; a título informativo, se incorpora en la página web del Sistema: http://es.csostenible.net/dapc

Declaración Ambiental de Producto Panel ECO 50 D
Resumen ejecutivo

SISTEMA DAPc

Declaraciones Ambientales de Producto en el sector de la Construcción
http://es.csostenible.net

ADMINISTRADOR DEL SISTEMA

Col·legi d'Aparelladors, Arquitectes Tècnics i Enginyers d'Edificació (CAATEEB)
C. Bon Pastor, 5, 08021 Barcelona
www.apabcn.cat

TITULAR DE LA DECLARACIÓN

Saint-Gobain Cristalería, S.A, División Aislamiento-ISOVER,
Azuqueca de Henares, 19200 Guadalajara

DECLARACIÓN REALIZADA POR:
GiGa-(Escola Superior de Comerç Internacional-Universitat Pompeu Fabra)
Calle Pujades 1, 08003, Barcelona - España

NÚMERO DE DECLARACIÓN	DAPc 001.001
PRODUCTO DECLARADO	Panel ECO 50 D

DESCRIPCIÓN DEL PRODUCTO

El producto ECO 50 D es un panel compacto de lana de vidrio no hidrófila, sin revestimiento, de 50 mm de espesor, 1350 mm de longitud, 600 mm de ancho y 18 kg/m^3 de densidad.

FECHA DE REGISTRO	28.10.2010

VALIDEZ

Esta declaración verificada autoriza a su titular a llevar el logo del sistema de ecoetiquetado DAPc. La declaración es aplicable exclusivamente al producto mencionado y durante cinco años a partir de la fecha de registro. La información contenida en esta declaración ha sido suministrada bajo responsabilidad de ISOVER.

FIRMA CAATEEB	FIRMA VERIFICADOR ACREDITADO
Sra. Rosa Remolà, presidenta del CAATEEB	Sr. Xavier Folch, auditor acreditado del ITeC
COL·LEGI D'APARELLADORS, ARQUITECTES TÈCNICS I ENGINYERS D'EDIFICACIÓ DE BARCELONA	ITeC Institut de Tecnologia de la Construcció de Catalunya XAVIER FOLCH

Esta declaración ambiental de producto cumple las normas ISO 14025 e ISO 21930 y describe información de carácter ambiental relativa al ciclo de vida del producto Panel de lana de vidrio ECO 50 D fabricado por ISOVER en su planta de Azuqueca de Henares (Guadalajara). Esta declaración se basa en el documento *RCP 001 Productos aislantes térmico - Versión 1 – 2010.06.11.*

Declaración Ambiental de Producto Panel ECO 50 D

1. Descripción del producto y de su uso

El producto ECO 50 D es un panel compacto de lana de vidrio no hidrófila, sin revestimiento, de 50 mm de espesor, 1350 mm de largo y 600 mm de ancho.

Sus especificaciones técnicas son:

Tabla 1. **Especificaciones técnicas.**		
Espesor (mm)	50	
Ancho (mm)	600	
Largo (mm)	1350	
Resistencia térmica (m^2 K/W)	1,30	
Conductividad térmica (W/mk)	0,038	
Peso (kg)	0,729	
Densidad (kg/m^3)	18	

El principal uso recomendado para este producto es el aislamiento térmico y acústico en cerramientos de fachada con cámara. Además, el producto es no inflamable y tiene un poder calorífico mínimo, de manera que se opone a la propagación de incendios.

2. Descripción de las etapas de ciclo de vida

2.1. Fabricación (A1, A2 y A3)

Materias primas (A1 y A2)

La lana de vidrio fabricada por ISOVER está compuesta fundamentalmente por calcín (vidrio reciclado), por vidrio reciclado externo procedente de la trituración de cristales de ventanas de la construcción y por una mezcla de materiales vitrificantes, fundentes y estabilizantes que confieren determinadas propiedades al producto. A esta base mineral se añade un 6% aproximadamente de agente de encolado (peso en húmedo) consistente en una resina fenólica modificada. Además, se utiliza plástico, papel y madera para el embalaje de la pieza acabada.

Las materias primas utilizadas tienen orígenes diferentes (local, nacional, europeo o intercontinental). Esta variación es debida a la imposibilidad de obtener dichas materias primas de un mismo origen. Casi todos los transportes se realizan por carretera en camiones de gran tonelaje, a excepción del bórax que es transportado parcialmente en barco. En general, para los transportes por carretera de las materias primas se han escogido modelos de camiones de 27 t de capacidad que cumplen con la normativa Euro III y que utilizan combustible producido en España.

Para el transporte por barco se considera un barco transoceánico con una carga de 27.500 TPM (toneladas de peso muerto). Todas las materias primas se transportan a granel, es decir, que no requieren material de embalaje.

Fabricación (A3)

Desde la mezcladora, las materias primas se descargan en un silo y, desde éste y mediante un sistema de cintas transportadoras, se introducen en un depósito más pequeño. A continuación, una máquina "enfornadora" (cinta transportadora) va introduciendo los materiales de manera homogénea en el horno de fusión. El horno se alimenta de electricidad procedente de la red. Una vez fundido el chorro cae dentro del disco de fibrado. La fabricación del panel propiamente dicho se desarrolla en tres etapas básicas:

- Producción de la manta: las fibras empapadas con material de encolado caen sobre una cinta transportadora en movimiento.
- Estufa de polimerización. La manta pasa a través de la estufa de polimerización, que funciona con quemadores de gas natural, en la que dos tapices la comprimen y en la que se inyecta aire caliente.
- Recorte lateral y conformado. Una vez fuera de la estufa, la manta pasa por unas cintas a la zona de enfriamiento en la que se inyecta aire para hacer que pierda temperatura más rápidamente.

Una vez conformado, el panel es embalado utilizando láminas de polietileno y se etiqueta. El producto se comprime varias veces para disminuir su volumen durante el almacenaje y transporte. Finalmente, se paletiza. Durante el proceso de fabricación se generan restos de vidrio fundido y recortes laterales del producto acabado que son reintroducidos en distintos puntos del mismo. También se generan residuos que son enviados a reciclar externamente, como por ejemplo residuos de lana húmedos o los discos de fibrado. Las aguas residuales producidas son recuperadas y reutilizadas en el proceso de fabricación. El aporte de agua de red tiene la finalidad de compensar las pérdidas por evaporación y de agua que queda atrapada en las fibras del panel.

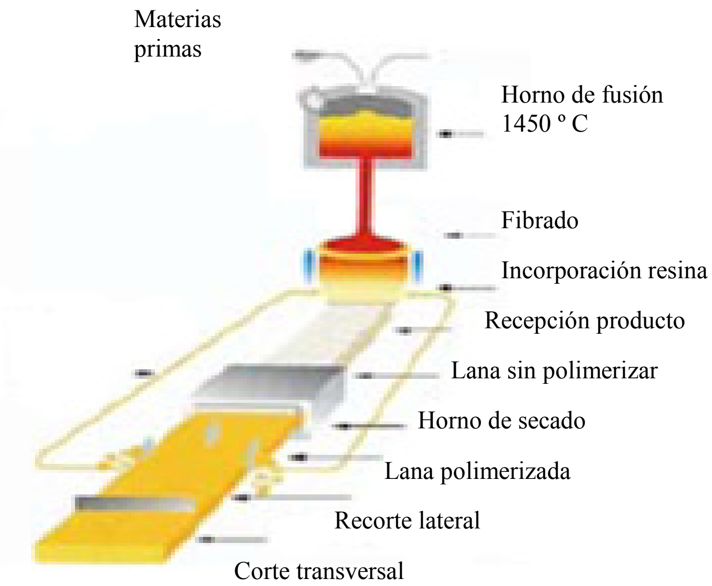

Figura 1. **Proceso de fabricación del producto lana de vidrio ECO 50 D.**

2.2. Construcción

Transporte del producto (A4)

El transporte se realiza en camiones en los que se transportan 18 palés de dimensiones 1,19 m (ancho) x 1,35 m (largo) x 2,40 m (altura). Se ha considerado una distancia media de 380 km entre la fábrica y el lugar de instalación. El camión utilizado cumple la normativa EURO III, consume 0,21 kg de diésel/kg de carga transportada y la tasa de retorno es del 30 %.

Proceso de instalación del producto y construcción (A5)

Una vez el producto es descargado del camión, se desembala y se procede a su instalación. Un proceso típico de instalación del panel de lana de vidrio ECO 50 D consiste en:

1. **Preparación del soporte** para la aplicación del producto asegurando que está limpio e igualado en la superficie.
2. **Proyección del mortero en la superficie.** Se necesitarán aproximadamente 6 litros de agua por saco de mortero. El mortero se puede proyectar con máquina o a mano en lugares de difícil acceso. Posteriormente se deberá uniformizar la superficie hasta conseguir un espesor de 3 a 5 mm. Temperatura de aplicación: 5-35º C.
3. **Instalación del panel.** Los paneles se deberán colocar mediante presión manual mientras el mortero está fresco. Una vez instalados los paneles aislantes, se cierra la cámara mediante trasdosada con ladrillo hueco cerámico o con placa de yeso laminado.

Se estima que las mermas de producto generadas durante su instalación son del 5%. Además de estas mermas, durante la instalación del panel se generan los residuos de embalaje. Se ha estimado que todos estos residuos se llevan a un vertedero controlado situado a 50 km de la obra.

2.3. Uso del producto

La etapa de uso se divide en los siguientes módulos:

- Uso (B1)
- Mantenimiento (B2)
- Reparación (B3)
- Substitución (B4)
- Rehabilitación (B5)
- Uso de la energía operacional (B6)
- Uso del agua operacional (B7)

Una vez instalado, el producto no requiere de ningún aporte energético ni material a lo largo de su etapa de uso para su correcto funcionamiento. Por otro lado, este producto no queda expuesto al ambiente interior del edificio ni está en contacto con corrientes de agua ni con el suelo. Por todo ello, no se contemplan cargas ambientales atribuibles a ninguno de los módulos anteriormente mencionados.

La vida útil de referencia del producto es la misma que la del edificio donde se encuentre instalado, puesto que si se instala correctamente, su durabilidad y su emplazamiento, hacen que su substitución no sea necesaria ni practicable.

2.4. Fin de vida

La etapa de fin de vida incluye los siguientes módulos:

- Deconstrucción y derribo (C1)
  Una vez finalizada su vida útil, el producto será retirado, ya sea en el marco de una rehabilitación del edificio o bien durante su demolición. En el marco del derribo de un edificio, los impactos atribuibles a la desinstalación del producto panel de lana de vidrio ECO 50 D son despreciables.
- Transporte (C2)
  Los residuos del producto se transportan en camión que cumple la normativa Euro III, a una distancia de 50 km hasta su destino.
- Gestión de residuos para reutilización, recuperación y reciclaje (C3)
  Aunque el producto panel de lana de vidrio ECO 50 D es reciclable, actualmente el reciclaje de este tipo de productos no es una práctica habitual en España. Por ello, se considera que el producto se lleva a eliminación final en su totalidad.
- Eliminación final (C4)
  El residuo del producto se elimina en un vertedero controlado de residuos de la construcción inertes.

2.5. Módulo D: beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

En el presente módulo D se declara la existencia de créditos ambientales (esto es, impactos ambientales evitados) debido a la reutilización, recuperación o reciclaje de algunos de los flujos de salida del sistema. Se declarará los impactos netos resultantes de contabilizar los impactos de producción de los materiales o combustibles primarios desplazados o substituidos menos las cargas ambientales de las operaciones de reutilización, recuperación y reciclaje.

Se ha considerado únicamente dos reciclajes de residuos: los discos de fibrado y los residuos de la lana de vidrio húmeda que se envía a reciclar en la línea de lana de roca que tiene ISOVER en el mismo polígono industrial.

3. Análisis de Ciclo de Vida

El análisis del ciclo de vida en el que se basa esta declaración se ha realizado siguiendo las normas ISO 14040 e ISO 14044 y el documento *RCP 001 Productos aislantes térmicos - Versión 1 – 2010.06.11.*

Este ACV es del tipo "**de la cuna a la tumba**", es decir, que abarca las etapas de fabricación del producto, construcción, uso y fin de vida.

Se han utilizado datos específicos de la planta de Azuqueca de Henares (Guadalajara) correspondientes al año 2008 para inventariar la etapa de fabricación. Para el resto de etapas se han utilizado datos genéricos procedentes en su mayoría de la base de datos oficial del sistema DAPc y la base de datos ELCD.

3.1. Unidad funcional

La unidad funcional es *"aislamiento térmico de 1m^2 de fachada durante 50 años utilizando el producto panel ECO 50 D con una resistencia térmica de 1,30 m^{2}K/W y considerando un entorno geográfico y tecnológico de España en el año 2010".*

3.2. Límites del sistema

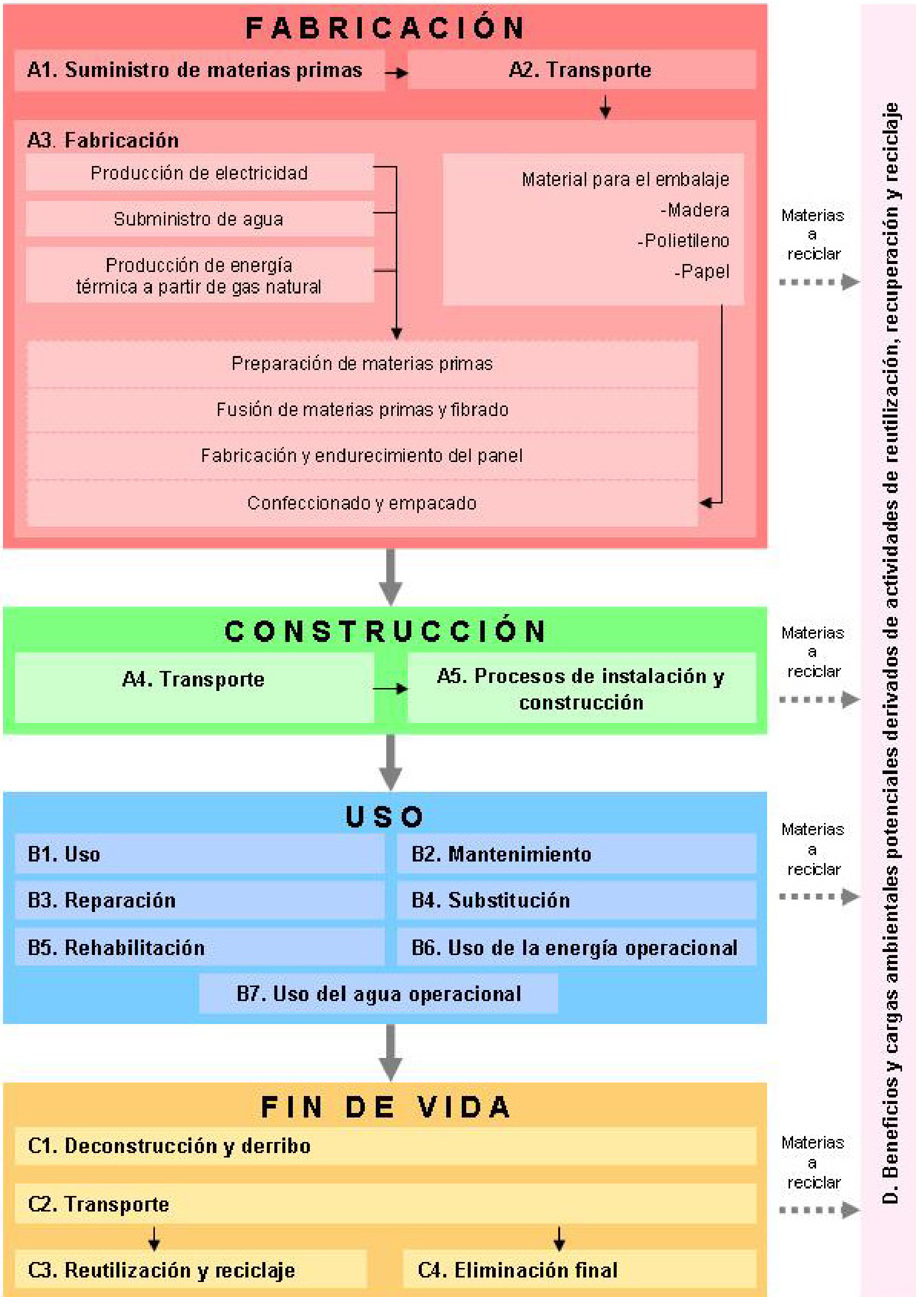

Figura 2. **Límites del sistema.**

3.3. Indicadores de la evaluación de impactos

Tabla 2. **Indicadores de la evaluación de impacto**

Parámetro evaluado	**Unidad por m² de panel**	**Etapa del ciclo de vida**													
		Fabricación	**Construcción**		**Uso**							**Fin de vida**			
		A1. – A3.	**A4.**	**A5.**	**B1.**	**B2.**	**B3.**	**B4.**	**B5.**	**B6.**	**B7.**	**C1.**	**C2.**	**C3.**	**C4.**
Potencial de Calentamiento Global	kg de CO_2 eq.	1,73E+00	8,20E-01	2,74E-01	-	-	-	-	-	-	-	-	4,67E-03	0,00E+00	1,74E-02
Potencial de Agotamiento de Ozono Estratosférico	Kg de CFC11 eq.	1,75E-07	1,57E-09	4,51E-09	-	-	-	-	-	-	-	-	8,94E-12	0,00E+00	1,50E-10
Potencial de Acidificación	Kg de SO_2 eq.	1,09E-02	5,36E-03	4,17E-04	-	-	-	-	-	-	-	-	2,90E-05	0,00E+00	7,44E-05
Potencial de Eutrofización	Kg de PO_4^{3-} eq.	1,19E-03	8,54E-04	2,83E-04	-	-	-	-	-	-	-	-	4,57E-06	0,00E+00	9,82E-06
Potencial de Agotamiento de Recursos Abióticos	Kg de Sb eq.	1,37E-02	5,51E-03	5,45E-04	-	-	-	-	-	-	-	-	3,14E-05	0,00E+00	6,65E-05
Potencial de Formación de Ozono Fotoquímico	kg de etano eq.	9,37E-04	4,88E-04	7,62E-05	-	-	-	-	-	-	-	-	2,45E-06	0,00E+00	1,18E-05

A1. Suministro de materias primas
A2. Transporte
A3 Fabricación (según figura 2)
A4. Transporte
A5. Procesos de instalación y construcción

B1. Uso
B2. Mantenimiento y transporte
B3. Reparación
B4. Substitución
B5. Rehabilitación
B6. Uso de la energía operacional
B7. Uso del agua operacional

C1. Deconstrucción y derribo
C2. Transporte
C3. Gestión de residuos para reutilización, recuperación y reciclaje.
C4. Eliminación final

-: las RCP no prevén el cálculo de este impacto al no ser relevante para este tipo de producto.

3.4. Datos de inventario de ciclo de vida (ICV)

Tabla 3. **Datos de inventario de ciclo de vida**

Parámetro evaluado	Unidad por m² de panel	Etapa del ciclo de vida													
		Fabricación	Construcción		Uso							Fin de vida			
		A1. – A3.	A4.	A5.	B1.	B2.	B3.	B4.	B5.	B6.	B7.	C1.	C2.	C3.	C4.
Consumo de energía primaria renovable	MJ (valor calorífico neto)	4,92E+00	2,14E-02	2,63E-02	-	-	-	-	-	-	-	-	1,22E-04	0,00E+00	9,69E-03
Consumo de energía primaria no renovable	MJ (valor calorífico neto)	3,50E+01	1,15E+01	1,30E+00	-	-	-	-	-	-	-	-	6,57E-02	0,00E+00	1,44E-01
Utilización de combustibles secundarios no renovables	MJ (valor calorífico neto)	0,00E+00	0,00E+00	0,00E+00	-	-	-	-	-	-	-	-	0,00E+00	0,00E+00	0,00E+00
Utilización de combustibles secundarios renovables	MJ (valor calorífico neto)	0,00E+00	0,00E+00	0,00E+00	-	-	-	-	-	-	-	-	0,00E+00	0,00E+00	0,00E+00
Consumo de agua dulce	m³	2,20E-02	3,39E-04	1,19E-03	-	-	-	-	-	-	-	-	1,93E-06	0,00E+00	2,39E-04
Producción de residuos	kg	2,77E+00	3,72E-02	1,09E+00	-	-	-	-	-	-	-	-	2,12E-04	0,00E+00	9,16E-01
Peligrosos	kg	8,59E-03	0,00E+00	5,33E-05	-	-	-	-	-	-	-	-	2,12E-04	0,00E+00	9,16E-01
No peligrosos	kg	2,77E+00	3,72E-02	1,09E+00	-	-	-	-	-	-	-	-	1,19E-07	0,00E+00	0,00E+00
Radioactivos	kg	2,27E-03	2,09E-05	5,86E-05	-	-	-	-	-	-	-	-	0,00E+00	0,00E+00	0,00E+00
Material de salida para	kg	7,15E-02	0,00E+00	0,00E+00	-	-	-	-	-	-	-	-	0,00E+00	0,00E+00	0,00E+00
Reutilización	kg	0,00E+00	0,00E+00	0,00E+00	-	-	-	-	-	-	-	-	0,00E+00	0,00E+00	0,00E+00
Reciclaje	kg	7,15E-02	0,00E+00	0,00E+00	-	-	-	-	-	-	-	-	0,00E+00	0,00E+00	0,00E+00
Valoración energética	kg	0,00E+00	0,00E+00	0,00E+00	-	-	-	-	-	-	-	-	0,00E+00	0,00E+00	0,00E+00

A1. Suministro de materias primas
A2. Transporte
A3 Fabricación (según figura 2)
A4. Transporte
A5. Procesos de instalación y construcción

B1. Uso
B2. Mantenimiento y transporte
B3. Reparación
B4. Substitución
B5. Rehabilitación
B6. Uso de la energía operacional
B7. Uso del agua operacional

C1. Deconstrucción y derribo
C2. Transporte
C3. Gestión de residuos para reutilización, recuperación y reciclaje.
C4. Eliminación final

-: *las RCP no prevén el cálculo de este impacto al no ser relevante para este tipo de producto.*

3.5. Beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

Anexo 1 - Tabla 2. **Indicadores de la evaluación de impacto**

Reutilización, recuperación y reciclaje		
Parámetro evaluado	**Unidad por m² de panel**	**D.**
Potencial de Calentamiento Glob	kg de CO_2 eq.	-2,94E-03
Potencial de Agotamiento de Ozono Estratosférico	Kg de CFC11 eq	-7,10E-11
Potencial de Acidificación	Kg de SO_2 eq.	-8,66E-06
Potencial de Eutrofización	Kg de PO_4^{3-} eq.	-9,80E-06
Potencial de Agotamiento de Recursos Abióticos	Kg de Sb eq.	-1,01E-05
Potencial de Formación de Ozono Fotoquímico	kg de etano eq.	-7,29E-07

D. Beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

Anexo 1 - Tabla 3. **Datos de inventario de ciclo de vida**

Reutilización, recuperación y reciclaje		
Parámetro evaluado	**Unidad por m² de panel**	**D.**
Consumo de energía primaria renovable	MJ (valor calorífico neto)	-8,34E-04
Consumo de energía primaria no renovable	MJ (valor calorífico neto)	-2,36E-02
Utilización de combustibles secundarios no renovables	MJ (valor calorífico neto)	0,00E+00
Utilización de combustibles secundarios renovables	MJ (valor calorífico neto)	0,00E+00
Consumo de agua dulce	m³	5,04E-06
Producción de residuos	kg	3,43E-12
Peligrosos	kg	0,00E+00
No peligrosos	kg	3,43E-12
Radioactivos	kg	0,00E+00
Material de salida para	kg	0,00E+00
Reutilización	kg	0,00E+00
Reciclaje	kg	0,00E+00
Valoración energética	kg	0,00E+00

D. Beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

3.6. Recomendaciones sobre el uso de esta DAP

La comparación de productos de la construcción se debe hacer aplicando la misma unidad funcional y a nivel de edificio, es decir, incluyendo el comportamiento del producto a lo largo de todo su ciclo de vida.

Las declaraciones ambientales de producto de diferentes sistemas de ecoetiquetado tipo III no son directamente comparables, puesto que las reglas de cálculo pueden ser diferentes.

La presente declaración representa el comportamiento medio del producto de lana de vidrio panel ECO 50 D.

3.7. Reglas de corte

Se ha incluido más del 95% de todas las entradas y salidas de masa y energía del sistema, quedando fuera únicamente uno de los componentes del panel (aceite) al no disponer de datos sobre su fabricación, así como las emisiones difusas generadas en fábrica debido a la incertidumbre y dificultad para su contabilización.

3.8. Otros datos

Los residuos de lana mineral están incluidos como "residuos no peligrosos" en la lista europea de residuos con código CER 170604: "Materiales de aislamiento distintos a los especificados en los códigos 170601 y 170603" (Directiva 2000/532/CE).

4. Información técnica y escenarios

A) Transporte

Parámetro	**Parámetro expresado por unidad funcional**
Consumo de combustible o vehículo de transporte utilizado	5,13E-04 l/km
Capacidad de utilización (incluyendo la vuelta llenas)	15 %
Densidad de carga del producto transportado	56,90 kg/m^3
Factor de cálculo de la capacidad del volumen utilizado.	0,80

B) Procesos de instalación

Parámetro	**Parámetro expresado por unidad funcional**
Materiales auxiliares para la instalación	Mortero: 1,75 kg
Consumo de otros recursos	Agua: 0,42 kg
Descripción cuantitativa del tipo de energía y el consumo durante el proceso de instalación del producto	No se detectan
Residuos en el lugar de construcción, generados por la instalación del producto	Asimilado todo a disposición final Mermas del producto 0,0180 kg Pale 3,45 E-04 kg Polietileno 4,49 E-02 kg Madera 6,39 E-02 kg
Salidas materiales como resultado de los procesos de gestión de los residuos en el lugar de la instalación. Por ejemplo: de recopilación para el reciclaje, para la recuperación energética, y la eliminación final	Asimilado todo a disposición final Mermas del producto 0,0180 kg Pale 3,45 E-04 kg Polietileno 4,49 E-02 kg Madera 6,39 E-02 kg
Emisiones al aire, suelo y agua	No se detectan

C) Uso operacional de energía y agua

Parámetro	Parámetro expresado por unidad funcional
Tipo de energía, por ejemplo: electricidad, gas natural, aprovechamiento de calor para un distrito	No se detecta
Salidas	No se detecta
Consumo neto de agua fresca	No se detecta
Representación característica (eficiencia energética, emisiones, etc)	No se detecta
Vida de servicio de referencia	50 años

D) Mantenimiento y reparación

Parámetro	Parámetro expresado por unidad funcional
Mantenimiento, por ejemplo; agente de limpieza, tipo de surfactante	No se detecta
Ciclo de mantenimiento	No se detecta
Entradas energéticas para el proceso de mantenimiento	No se detecta
Consumo neto de agua dulce durante el mantenimiento o la reparación	No se detecta
Inspección, mantenimiento o proceso de reparación	No se detecta
Inspección, mantenimiento o ciclo de reparación	No se detecta
Materiales auxiliares, ejemplo lubricante	No se detecta
Intercambio de partes durante el ciclo de vida del producto	No se detecta
Entradas de energía durante el mantenimiento, tipo de energía, ejemplo: electricidad, y cantidad	No se detecta
Entrada de energía durante el proceso de reparación, renovación, recambio si es aplicable y relevante	No se detecta
Pérdida de material durante el mantenimiento o reparación	No se detecta
Vida de servicio de referencia del producto para ser incluida como base para el cálculo del numero de recambios en el edificio	50 años

E) Fin de vida

Proceso	Parámetro expresado por unidad funcional de componentes, productos o materiales
Procesos de recopilación	0,9 kg recogidos conjuntamente con residuos de la construcción
Sistemas de reciclaje	No se detecta
Eliminación final	0,9 kg de material para la eliminación final incluyendo pérdidas de material.

5. Información adicional

Características técnicas del producto	- Marcado CE - Conductividad térmica: 0,038 W/mk - Resistencia térmica: 1,30 m^2 K/W - Ficha de seguridad
Transporte y construcción	- Densidad de la carga transportada: 56,90 kg/m^3 - Se requiere 1,75 kg de mortero y 0,42 kg de agua para la colocación de $1m^2$ de panel en obra
Uso y mantenimiento	- Vida útil de referencia (años): 50 años
Fin de vida	- Código CER del residuo según la lista europea de residuos (Directiva 2000/532/CE): CER 170604

- Certificado AENOR de producto N°020/002943 conforme a la UNE 13162:2002.
- Certificado del Sistema de gestión de Calidad ER-0043/1992.
- Certificado por la implementación de un Sistema de Calidad que cumple los requerimientos de la ISO 9001:2000.
- Certificado por la implementación de un Sistema de Gestión Ambiental que cumple los requerimientos de la ISO 14001.
- Declaración de conformidad CE (Directiva 89/106/CE sobre los productos de construcción).
- Certificado EUCEB.

6. RCP y verificación

Esta declaración se basa en el Documento *RCP 001 Productos aislantes térmicos - V.1.*

La revisión de la *RCP 001 Productos aislantes térmicos - V.1.* fue realizada por el Consejo asesor del sistema DAPc, presidido por la Sra. Núria Pedrals (Direcció General de Qualitat de l'Edificació i Rehabilitació de l'Habitatge- Departament de Medi Ambient i Habitatge- Generalitat de Catalunya)
Verificación independiente de la declaración y de los datos, de acuerdo con la norma ISO 14025:2006 ☐ interna ☒ externa
Verificador de tercera parte: - Xavier Folch Berenguer, ITeC Oficina d'**Acreditació** d'Entitats Col·laboradores **Verificació VEDAP-001-10**
Fecha de la verificación : 28 de octubre de 2010

Referencias

- Análisis de Ciclo de Vida del panel lana de vidrio ECO 50 D. GiGa (ESCI-UPF) para ISOVER 2010 (no publicado).

ADMINISTRADOR DEL SISTEMA

Col·legi d'Aparelladors, Arquitectes Tècnics i Enginyers de l'Edificació de Barcelona (CAATEEB)

Bon Pastor 5, 08021 Barcelona.

www.apabcn.cat

EMAS
GESTIÓ AMBIENTAL VERIFICADA
REG. No. 000142

UNE-EN-ISO 14001
DNV
EMPRESA CERTIFICADA

DECLARACIÓN AMBIENTAL DE PRODUCTO

DAPc® 001.005

DE ACUERDO CON LAS NORMAS
ISO 14.025 e ISO 21.930

PRODUCTO

ULTRACOUSTIC R de 70 mm

EMPRESA

KNAUF INSULATION

DESCRIPCIÓN DEL PRODUCTO

Panel compacto en rollo de Lana Mineral de Vidrio no hidrófila, sin revestimiento, de 70 mm de espesor nominal y 400/600 mm de anchura

RCP DE REFERENCIA

RCP001 - Productos aislantes térmicos – V.1 (2010)

PLANTA PRODUCCIÓN

KNAUF INSULATION LANNEMEZAN SAS
501, Voie Napoléon III
F-65300 Lannemezan (France)

VALIDEZ

Desde: 31.01.2013
Hasta: 30.01.2018

La validez de la DAPc® 001.005 está sujeta a las condiciones del reglamento DAPc®. La edición vigente de esta DAPc® es la que figura en el registro que mantiene CAATEEB; a título informativo, se incorpora en la página web del Sistema http://es.csostenible.net/dapc

Página en blanco

Declaración Ambiental de Producto ULTRACOUSTIC R de 70 mm
Resumen ejecutivo

SISTEMA DAPc®

Declaraciones Ambientales de Producto en el sector de la Construcción
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ADMINISTRADOR DEL SISTEMA

Col·legi d'Aparelladors, Arquitectes Tècnics i Enginyers d'Edificació (CAATEEB)
C. Bon Pastor, 5, 08021 Barcelona
www.apabcn.cat

TITULAR DE LA DECLARACIÓN

KNAUF INSULATION SL
c/ La Selva, 2
E-08820 El Prat de Llobregat-Barcelona (España)

DECLARACIÓN REALIZADA POR:
KNAUF INSULATION SPRL / 95, Rue de Maastricht / B-4600 Visé (Belgique)

NÚMERO DE DECLARACIÓN	DAPc® 001.005
PRODUCTO DECLARADO	ULTRACOUSTIC R de 70 mm

DESCRIPCIÓN DEL PRODUCTO

Panel compacto en rollo de Lana Mineral de Vidrio no hidrófila, sin revestimiento, de 70 mm de espesor nominal y 400/600 mm de anchura.

FECHA DE REGISTRO	31.01.2013

VALIDEZ

Esta declaración verificada autoriza a su titular a llevar el logo del sistema de ecoetiquetado DAPc®. La declaración es aplicable exclusivamente al producto mencionado y durante cinco años a partir de la fecha de registro. La información contenida en esta declaración ha sido suministrada bajo responsabilidad de KNAUF INSULATION.

FIRMA CAATEEB	FIRMA VERIFICADOR ACREDITADO
Sra. Rosa Remolà, presidenta del CAATEEB	Sr. Xavier Folch, auditor acreditado del ITEC
COL·LEGI D'APARELLADORS, ARQUITECTES TÈCNICS I ENGINYERS D'EDIFICACIÓ DE BARCELONA	ITeC Institut de Tecnologia de la Construcció de Catalunya XAVIER FOLCH

Esta declaración ambiental de producto cumple las normas ISO 14025 e ISO 21930 y describe información de carácter ambiental relativa al ciclo de vida del producto ULTRACOUSTIC R de 70 mm fabricado por KNAUF INSULATION en su planta de Lannemezan (France). Esta declaración se basa en el documento *RCP Productos aislantes térmicos – versión 1 – 2010.06.11*

Declaración Ambiental de Producto ULTRACOUSTIC R de 70 mm

1. Descripción del producto y de su uso

El producto ULTRACOUSTIC R es un panel compacto en rollo de Lana Mineral de Vidrio no hidrófila, sin revestimiento, de 70 mm de espesor y 400/600 mm de anchura.

Sus especificaciones técnicas son:

Tabla 1. **Especificaciones técnicas**		
Espesor nominal (mm)	70	
Anchura nominal (mm)	400 y 600	
Longitud nominal (mm)	5.250	
Resistencia térmica declarada (m^2.K/W)	1,85	
Conductividad térmica declarada (W/m.K)	0,037	

La principal aplicación de este producto es el aislamiento termo-acústico de divisiones verticales interiores constituidas por entramado metálico y placas de yeso laminado. Además, el producto es no combustible (Euroclase A1) y tiene un poder calorífico mínimo, de manera que no contribuye a la propagación de incendios.

2. Descripción de las etapas de ciclo de vida

2.1. Fabricación (A1, A2 y A3)

Materias primas (A1 y A2)

La Lana Mineral de Vidrio fabricada por KNAUF INSULATION está compuesta por una mezcla de vitrificantes, fundamentalmente arena de sílice, vidrio reciclado externo de distinta procedencia y residuos de fabricación, de fundentes y de estabilizantes que confieren determinadas propiedades al producto. A esta base mineral se añade un porcentaje determinado de un ligante natural de origen vegetal (**Ecose® Technology**).

Las materias primas utilizadas son suministradas por proveedores locales, nacionales e internacionales respecto de la zona donde se encuentra ubicada la planta de producción. Todos los transportes se realizan por carretera en camiones de gran tonelaje. En general, se han escogido modelos de camiones de 27 t (25 t en Francia) de capacidad, que cumplen con la normativa de emisiones Euro V. La mayoría de materias primas se transportan en camiones cisterna.

Fabricación (A3)

La fabricación es un proceso continuo constituido por las siguientes fases:
– Dosificación y mezcla de materias primas: Las materias primas se almacenan en silos, y se dosifican y mezclan por métodos automatizados.

– Horno de fusión: Las materias primas, una vez mezcladas, se introducen en un horno de fusión y mediante la aportación de energía primaria, se funden a temperaturas superiores a los 1.000 ºC para obtener un magma o masa líquida.
– Fibrado del magma: El magma cae sobre unas cacerolas metálicas perforadas en sus bordes (“spinners”) y, mediante un proceso de centrifugado a gran velocidad y enfriamiento rápido, se obtienen filamentos de longitudes y diámetros variables.
– Aplicación del ligante: En esta fase Knauf Insulation incorpora **Ecose® Technology** dentro de su proceso productivo de Lana Mineral de Vidrio y, mediante rociado por pulverización, aplica un ligante natural a base de almidón vegetal, exento de fenoles, formaldehidos u otros derivados del petróleo, con el que se aglutinan las fibras, que van depositándose multidireccionalmente sobre una cinta transportadora continua, obteniéndose un colchón de densidad y espesor uniformes.
– Horno de cocción: Al paso del colchón de lana por el horno de cocción, el producto es comprimido para obtener el espesor nominal final y la resina polimeriza mediante una corriente de aire caliente a una temperatura de 250 °C.
– Fase de corte: El producto es cortado longitudinal y transversalmente mediante sierra y guillotina respectivamente, para obtener la longitud y la anchura nominales finales. La merma de producto procedente del perfilado lateral longitudinal se recicla para la fabricación de productos especiales.
– Embalaje y etiquetado: Para su transporte y acopio, el producto es comprimido, embalado en paquetes de paneles con films de polietileno retráctil y etiquetado para su identificación. Finalmente se paletiza en palets de madera y el conjunto se envuelve de nuevo con plástico impermeable, posibilitando su almacenamiento opcional a la intemperie.

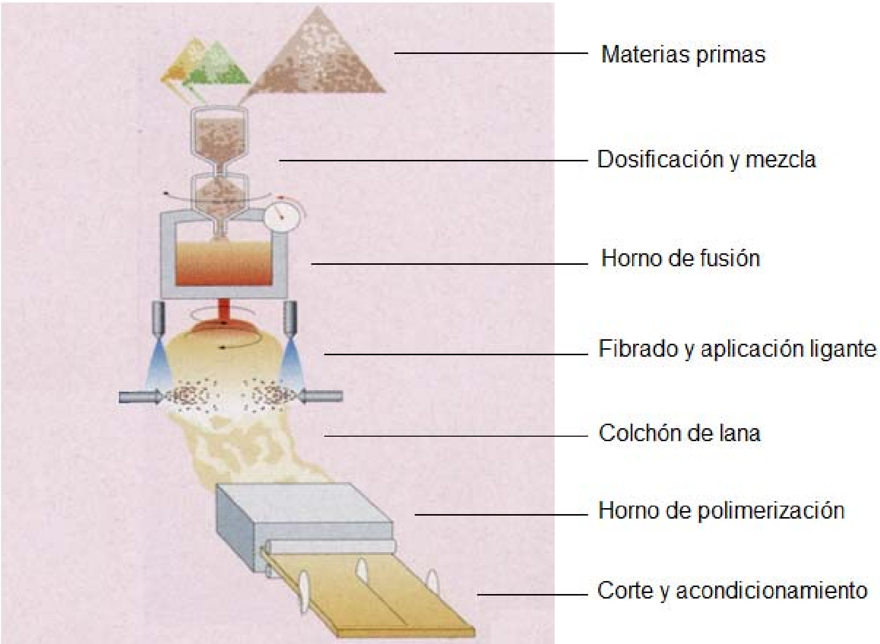

Figura 1. **Proceso de fabricación del producto ULTRACOUSTIC R**

2.2. Construcción

Transporte del producto (A4)

El transporte se realiza en camiones que transportan 22 palés de dimensiones 1,25 m (ancho) x 1,35 m (largo) x 2,40 m (alto). Se ha considerado una distancia media de 500 km entre la fábrica y el lugar de instalación. El camión utilizado cumple la normativa Euro V, consume 0,02 kg de diesel por kg de carga transportada y la tasa de retorno en vacío es del 10%.

Proceso de instalación del producto y construcción (A5)

Una vez el producto es descargado del camión se desembala y se procede a su instalación. El proceso habitual de instalación in situ de ULTRACOUSTIC R en divisiones verticales interiores es el siguiente:

1/ Comprobación del soporte, normalmente el trasdós de un aplacado a base de uno o dos gruesos de placas de yeso laminado, fijadas mecánicamente sobre un entramado metálico constituido por perfiles horizontales inferior y superior (canales) y perfiles verticales (montantes), asegurándonos que la anchura del producto ULTRACOUSTIC R suministrado en obra, ya sea 400 ó 600 mm, se corresponde con la distancia modulada entre montantes.
2/ Desenrollado y corte transversal con cuchillo o cúter de uso corriente, de los paneles de ULTRACOUSTIC R a la longitud necesaria, la cual se corresponderá con la altura de la división interior a construir.
3/ Colocación de los paneles de ULTRACOUSTIC R sobre el soporte y entre montantes, quedando sujetos a presión entre las pestañas de los perfiles horizontales y verticales.
4/ Una vez instalados los paneles de ULTRACOUSTIC R según se acaba de describir, quedan confinados dentro de la división vertical, al cerrar el conjunto con un segundo aplacado a base de uno o dos gruesos de placas de yeso laminado, igualmente fijadas mecánicamente sobre el mencionado entramado metálico.

Se estima que las mermas de producto generadas durante su instalación son del 2%. Además de estas mermas, se generan residuos de embalaje: madera, polietileno y papel/cartón. Se ha estimado que todos estos residuos se transportan en camión hasta un vertedero controlado situado a 50 km del lugar de la instalación.

Figura 2: **Solución constructiva. Instalación de ULTRACOUSTIC R en divisiones interiores a base de entramado metálico y placas de yeso laminado**

2.3. Uso del producto

La etapa de uso se divide en los siguientes módulos:
- Uso (B1)
- Mantenimiento (B2)
- Reparación (B3)
- Substitución (B4)
- Rehabilitación (B5)

- Uso de la energía operacional (B6)
- Uso del agua operacional (B7)

Una vez instalado, el producto no requiere de ningún aporte energético ni material a lo largo de su etapa de uso para su correcto funcionamiento. Por otro lado, este producto no queda expuesto al ambiente interior del edificio ni está en contacto con corrientes de agua ni con el suelo. Por todo ello, no se contemplan cargas ambientales atribuibles a ninguno de los módulos anteriormente mencionados.

La vida útil de referencia del producto es la misma que la del edificio donde se encuentre instalado, puesto que si se instala correctamente, su durabilidad y la dificultad de acceso, hacen que su substitución no sea necesaria ni practicable.

2.4. Fin de vida

La etapa de fin de vida incluye los siguientes módulos:

- Deconstrucción y derribo (C1)
  Una vez finalizada su vida útil, el producto será retirado, ya sea en el marco de una rehabilitación del edificio o bien durante su demolición. En el marco del derribo de un edificio, los impactos atribuibles a la desinstalación del producto son despreciables.

- Transporte (C2)
  Los residuos del producto se transportan en camión que cumple la normativa Euro III, a una distancia de 50 km hasta su destino.

- Gestión de residuos para reutilización, recuperación y reciclaje (C3)
  Aunque el producto ULTRACOUSTIC R es reciclable, actualmente el reciclaje de este tipo de productos no es una práctica habitual en España. Por ello, se considera que el producto se lleva a eliminación final en su totalidad.

- Eliminación final (C4)
  El residuo del producto se elimina en un vertedero controlado de residuos de la construcción inertes.

2.5. Módulo D: beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

Los resultados para el módulo D son nulos ya que no se han considerado materiales a reciclar y, por tanto, sus beneficios y cargas ambientales potenciales son iguales a cero.

3. Análisis de Ciclo de Vida

El análisis del ciclo de vida en el que se basa esta declaración se ha realizado siguiendo las normas ISO 14040 e ISO 14044 y el documento *RCP 001 productos aislantes térmicos. Versión 1 – 2010.06.11.*

Este ACV es del tipo **“de la cuna a la tumba”**, es decir, que abarca las etapas de fabricación del producto, construcción, uso y fin de vida.

Se han utilizado datos específicos de la planta de Lannemezan (Francia) correspondientes al período octubre 2010 – mayo 2011 para inventariar la etapa de fabricación. Para el resto de etapas se han utilizado datos genéricos procedentes de la base de datos de PE International suministradas con el software GaBi 5.

3.1. Unidad funcional

La unidad funcional es *"aislamiento térmico de 1 m^2 de fachada durante 50 años utilizando el producto ULTRACOUSTIC R con una resistencia térmica de 1,85 m^2.K/W y considerando un entorno geográfico y tecnológico de España en el año 2012".*

3.2. Límites del sistema

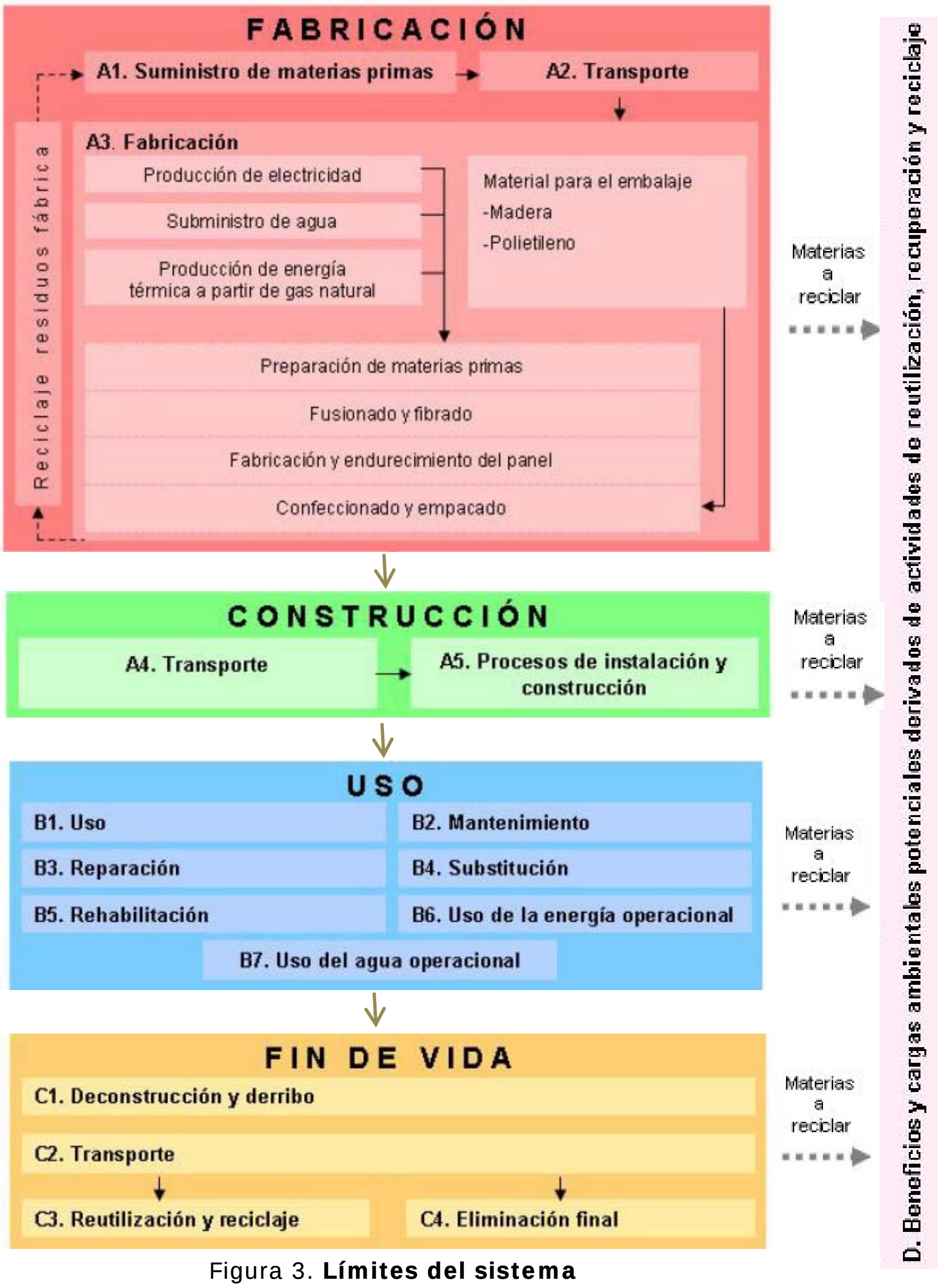

Figura 3. **Límites del sistema**

3.3. Indicadores de la evaluación de impactos

Tabla 2. **Indicadores de la evaluación de impacto**

Parámetro evaluado	Unidad por m^2 de panel	Etapa del ciclo de vida													
		Fabricación	Construcción		Uso							Fin de vida			
		A1. - A3.	A4.	A5.	B1.	B2.	B3.	B4.	B5.	B6.	B7.	C1.	C2.	C3.	C4.
Potencial de Calentamiento Global	kg de CO_2 eq.	9,58E-01	1,28E-01	6,13E-02	–	–	–	–	–	–	–	–	3,57E-03	0,00E+00	1,56E-01
Potencial de Agotamiento de Ozono Estratosférico	kg de CFC11 eq.	1,92E-07	4,76E-11	1,26E-11	–	–	–	–	–	–	–	–	1,32E-12	0,00E+00	3,17E-11
Potencial de Acidificación	kg de SO_2 eq.	6,02E-03	1,42E-04	1,30E-05	–	–	–	–	–	–	–	–	4,56E-06	0,00E+00	1,21E-04
Potencial de Eutrofización	kg de PO_4^{3}-eq.	1,18E-03	1,87E-05	5,39E-06	–	–	–	–	–	–	–	–	6,88E-07	0,00E+00	2,08E-04
Potencial de Agotamiento de Recursos Abióticos	kg de Sb eq.	8,78E-03	8,52E-04	1,25E-05	–	–	–	–	–	–	–	–	2,37E-05	0,00E+00	1,30E-04
Potencial de Formación de Ozono Fotoquímico	kg de etano eq.	4,80E-04	2,27E-05	1,64E-06	–	–	–	–	–	–	–	–	9,82E-07	0,00E+00	4,57E-05

A1. Suministro de materias primas
A2. Transporte
A3. Fabricación (según figura 3)
A4. Transporte
A5. Procesos de instalación y construcción

B1. Uso
B2. Mantenimiento y transporte
B3. Reparación
B4. Substitución
B5. Rehabilitación
B6. Uso de la energía operacional
B7. Uso del agua operacional

C1. Construcción y derribo
C2. Transporte
C3. Gestión de residuos para reutilización, recuperación y reciclaje
C4. Eliminación final

–: las RCP no prevén el cálculo de este impactoal no ser relevante para este tipo de producto.

3.4. Datos de inventario de ciclo de vida (ICV)

Tabla 3. **Datos de inventario de ciclo de vida**

Parámetro evaluado	Unidad por m^2 de panel	Etapa del ciclo de vida													
		Fabricación	Construcción		Uso							Fin de vida			
		A1. - A3.	A4.	A5.	B1.	B2.	B3.	B4.	B5.	B6.	B7.	C1.	C2.	C3.	C4.
Consumo de energía primaria renovable	MJ (valor calorífico neto)	4,00E+00	6,94E-02	2,02E-03	–	–	–	–	–	–	–	–	1,93E-03	0,00E+00	1,91E-02
Consumo de energía primaria no renovable	MJ (valor calorífico neto)	2,82E+01	1,78E+00	2,91E-02	–	–	–	–	–	–	–	–	4,93E-02	0,00E+00	2,83E-01
Utilización de combustibles secundarios no renovables	MJ (valor calorífico neto)	0,00E+00	0,00E+00	0,00E+00	–	–	–	–	–	–	–	–	0,00E+00	0,00E+00	0,00E+00
Utilización de combustibles secundarios renovables	MJ (valor calorífico neto)	0,00E+00	0,00E+00	0,00E+00	–	–	–	–	–	–	–	–	0,00E+00	0,00E+00	0,00E+00
Consumo de agua dulce	m^3	2,82E-02	1,58E-04	1,51E-04	–	–	–	–	–	–	–	–	4,37E-06	0,00E+00	3,20E-04
Producción de residuos	kg	1,98E+00	6,26E-03	3,25E-02	–	–	–	–	–	–	–	–	1,74E-04	0,00E+00	1,19E+00
Peligrosos	kg	2,22E-04	0,00E+00	0,00E+00	–	–	–	–	–	–	–	–	0,00E+00	0,00E+00	0,00E+00
No peligrosos	kg	1,98E+00	6,26E-03	3,25E-02	–	–	–	–	–	–	–	–	1,74E-04	0,00E+00	1,19E+00
Radioactivos	kg	4,17E-03	2,47E-06	2,47E-06	–	–	–	–	–	–	–	–	6,87E-08	0,00E+00	4,99E-06
Material de salida para	kg	0,00E+00	0,00E+00	0,00E+00	–	–	–	–	–	–	–	–	0,00E+00	0,00E+00	0,00E+00
Reutilización	kg	0,00E+00	0,00E+00	0,00E+00	–	–	–	–	–	–	–	–	0,00E+00	0,00E+00	0,00E+00
Reciclaje	kg	0,00E+00	0,00E+00	0,00E+00	–	–	–	–	–	–	–	–	0,00E+00	0,00E+00	0,00E+00
Valoración energética	kg	0,00E+00	0,00E+00	0,00E+00	–	–	–	–	–	–	–	–	0,00E+00	0,00E+00	0,00E+00

A1. Suministro de materias primas
A2. Transporte
A3. Fabricación (según figura 3)
A4. Transporte
A5. Procesos de instalación y construcción

B1. Uso
B2. Mantenimiento y transporte
B3. Reparación
B4. Substitución
B5. Rehabilitación
B6. Uso de la energía operacional
B7. Uso del agua operacional

C1. Construcción y derribo
C2. Transporte
C3. Gestión de residuos para reutilización, recuperación y reciclaje
C4. Eliminación final

–: las RCP no prevén el cálculo de este impactoal no ser relevante para este tipo de producto.

3.5. Beneficios y cargas ambientales potenciales derivados de actividades de reutilización, recuperación y reciclaje

Los resultados para el módulo D son nulos, ya que no se han considerado materiales a reciclar y, por lo tanto, sus beneficios y cargas ambientales potenciales son iguales a cero.

3.6. Recomendaciones sobre esta DAP

La comparación de productos de la construcción se debe hacer aplicando la misma unidad funcional y a nivel de edificio, es decir, incluyendo el comportamiento del producto a lo largo de todo su ciclo de vida.

Las declaraciones ambientales de producto de diferentes sistemas de eco-etiquetado tipo III no son directamente comparables, puesto que las reglas de cálculo pueden ser diferentes.

La presente declaración representa el comportamiento medio del producto de Lana Mineral de Vidrio ULTRACOUSTIC R.

3.7. Reglas de corte

Se han incluido más del 95% de todas las entradas y salidas de masa y energía del sistema, conforme a las Reglas de Categoría de Producto RCP 001. Los únicos flujos omitidos, que representan cada uno de ellos menos del 1% de la energía total consumida en la planta, son las emisiones debidas al desgaste del horno (flujos que pueden omitirse al estar relacionados con los equipos), los consumos de energía relacionados con los carros elevadores que circulan por la planta y que consumen GLP (gas licuado de petróleo), el transporte de los empleados y los flujos relativos a material de oficina.

3.8. Otros datos

Los residuos de Lana Mineral están incluidos como “residuos no peligrosos” en la lista europea de residuos con código CER 170604: “Materiales de aislamiento distintos a los especificados en los códigos 170601 y 170603” (Directiva 2000/532/CE).

4. Información técnica y escenarios

A) Transporte

Parámetro	**Parámetro expresado por unidad funcional**
Consumo de combustible o vehículo de transporte utilizado	5,26E-05 l/km
Capacidad de utilización (incluyendo la vuelta llenas)	22%
Densidad de carga del producto transportado	88,85 kg/m^3
Factor de cálculo de la capacidad del volumen utilizado.	0,85

B) Procesos de instalación

Parámetro	**Parámetro expresado por unidad funcional**
Materiales auxiliares para la instalación	No se detectan
Consumo de otros recursos	No se detectan
Descripción cuantitativa del tipo de energía y el consumo durante el proceso de instalación del producto	No se detectan
Residuos en el lugar de construcción, generados por la instalación del producto	Asimilado todo a eliminación final Mermas producto: 2,43E-02 kg Madera palés: 1,52E-02 kg Polietileno: 1,20E-02 kg Papel/cartón: 1,75E-04 kg
Salidas materiales como resultado de los procesos de gestión de los residuos en el lugar de la instalación. Por ejemplo: de recopilación para el reciclaje, para la recuperación energética, y la eliminación final	Asimilado todo a eliminación final Mermas producto: 2,43E-02 kg Madera palés: 1,52E-02 kg Polietileno: 1,20E-02 kg Papel/cartón: 1,75E-04 kg
Emisiones al aire, suelo y agua	No se detectan

C) Uso operacional de energía y agua

Parámetro	**Parámetro expresado por unidad funcional**
Tipo de energía, por ejemplo: electricidad, gas natural, aprovechamiento de calor para un distrito	No se detecta
Salidas	No se detecta
Consumo neto de agua fresca	No se detecta
Representación característica (eficiencia energética, emisiones, etc.)	No se detecta
Vida de servicio de referencia	50 años

D) Mantenimiento y reparación

Parámetro	**Parámetro expresado por unidad funcional**
Mantenimiento, por ejemplo; agente de limpieza, tipo de surfactante	No se detecta
Ciclo de mantenimiento	No se detecta
Entradas energéticas para el proceso de mantenimiento	No se detecta

Consumo neto de agua dulce durante el mantenimiento o la reparación	No se detecta
Inspección, mantenimiento o proceso de reparación	No se detecta
Inspección, mantenimiento o ciclo de reparación	No se detecta
Materiales auxiliares, ejemplo lubricante	No se detecta
Intercambio de partes durante el ciclo de vida del producto	No se detecta
Entradas de energía durante el mantenimiento, tipo de energía, ejemplo: electricidad, y cantidad	No se detecta
Entrada de energía durante el proceso de reparación, renovación, recambio si es aplicable y relevante	No se detecta
Pérdida de material durante el mantenimiento o reparación	No se detecta
Vida de servicio de referencia del producto para ser incluida como base para el cálculo del numero de recambios en el edificio	50 años

E) Fin de vida

Proceso	**Parámetro expresado por unidad funcional de componentes, productos o materiales**
Procesos de recopilación	1,19 kg recogidos conjuntamente con residuos de la construcción
Sistemas de reciclaje	No se detecta
Eliminación final	1,19 kg de material para la eliminación final incluyendo pérdidas de material

5. Información adicional

Características técnicas del producto	- Marcado CE - Conductividad térmica: 0,037 W/m.K - Resistencia térmica: 1,85 m^2.K/W - Ficha de seguridad
Transporte y construcción	- Densidad de la carga transportada: 88,85 kg/m^3 - No se requiere ningún material ni energía para la colocación de 1 m^2 de panel en obra
Uso y mantenimiento	- Vida útil de referencia (años): 50 años
Fin de vida	- Código CER del residuo según lista europea de residuos (Directiva 2000/532/CE): CER 170604

- Certificado de conformidad CE (Directiva 89/106/CEE sobre los productos de construcción, modificada por la Directiva 93/68/CEE) nº 1163 – CPD – 0258.
- Certificado AENOR de producto nº 020/003171 conforme a la UNE 13162:2002.

- Certificado ACERMI de producto nº 02/016/142 en aplicación de las Reglas Generales del Certificado de producto y del Reglamento Técnico de la Certificación de los materiales aislantes térmicos.
- Certificado nº 188 para el derecho de uso de EUCEB (European Certification Board for Mineral Wool Products) Trademark, 2010.
- Certificado EUROFINS GOLD nº 2011-IACG-025 sobre calidad de aire interior (eco-etiqueta tipo I (ISO 14024)).

6. RCP y verificación

Esta declaración se basa en el Documento *RCP 001 Productos aislantes térmicos – V.1*

La revisión de la *RCP 001 Productos aislantes térmicos – v.1* fue realizada por el Consejo asesor del sistema DAPc®, presidido por la Sra. Núria Pedrals (Direcció General de Qualitat de l'Edificació i Rehabilitació de l'Habitatge – Departament de Medi Ambient i Habitatge – Generalitat de Catalunya)
Verificación independiente de la declaración y de los datos, de acuerdo con la norma ISO 14025:2006 ☐ interna ☒ externa
Verificador de tercera parte: - Xavier Folch i Berenguer, ITeC Verificació VEDAP-001-10
Fecha de la verificación: 28 de enero de 2013

Referencias

- Análisis del Ciclo de Vida del panel de Lana Mineral de Vidrio ULTRACOUSTIC R realizado por Knauf Insulation y por la Université de Liège, dpto. Génie Chimique, en 2012 (no publicado).

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Rolan

EPD®

ENVIRONMENTAL PRODUCT DECLARATION

Rolan rockwool insulation board

Sustainable solutions to energy conservation and environmental preservation

Prepared by (practitioner)
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and Sustainable Design

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1 Product related information

1.1 The company

Rolan Aislantes Minerales S.A. de C.V. is a company in the field of insulation; it was established in 1978 and is currently the leading manufacturer in Latin America of Rock Mineral Fiber under its brand Rolan. Rolan manufacturing plant is located in San Luis Potosí, Mexico and produces a complete range of products, such as: rock mineral wool, expanded and extruded polystyrene and complements its line of insulation products with other quality insulation materials such as cellular glass, elastomeric foam, expanded perlite, calcium silicate and fiberglass.

Aislantes Minerales also sells the necessary materials and accessories for the installation and finish such as aluminum, metal cladding and stainless steel banding and seals, mastics, adhesives, sealants and coatings. The company has the human resources, quality materials and state of the art technologies to provide solutions on thermal insulation and acoustics as well as technical advice.

1.2 Management and product certifications

Rolan has a quality management system in place, which has been certified with ISO 9001 by Bureau Veritas.

Rolan boards have been certified under the The Mexican Official Standard for Thermal insulation for buildings - test methods (NOM-018-ENER-2011).

In addition, complies with the following Mexican Official standards:

• The Mexican Official Standard for Energy Efficiency in Commercial Buildings' Envelope (NOM-008-ENER-2001)
• The Mexican Official Standard for Energy Efficiency in Industrial Thermal Insulation (NOM 009-ENER-1995)
• The Mexican Official Standard for Energy Efficiency in Residential Buildings' Envelope (NOM-020-ENER-2011)
• The Voluntary Mexican Standard Building Industry – Insulation – "R" Value for the Housing Envelope by Thermal Zone for Mexican Republic – Specification and Verification (NMX C-460-ONNCCE-2009).
• ASTM International Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing (ASTM C-665).

1.3 Rolan and the environment

Rolan Aislantes Minerales is committed to protect the environment and work towards sustainability and has implemented an environmental management system, that helps the company control and monitor the consumption of materials, energy and water and the emissions to air and water discharges. Rolan complies with the national standards of emissions to air (Maximum permissible levels of emission from solid particle stationary sources NOM-043-SEMARNAT-1993) and to water (Requirements and regulation for waste water discharge NMX-AA-003-1980).

Rolan´s products are excellent materials to achieve thermal efficiency in buildings due to the following characteristics:

• noncombustible
• high R value for energy savings and outstanding thermal performance
• chemically inert, so do not contribute to indoor air pollution
• asbestos free
• resistant to mold, fungal and bacterial growth
• excellent fire resistance
• CFC and HCFC free

The rock wool products are processed with a 70% recycled material from local sources.

1.4 Intended use

To provide information regarding to environmental performance of Rolan rockwool insulation board to clients and relevant stakeholders within the building sector

1.5 Product specifications

Mineral wool insulating materials exhibit a good insulating capacity, they are resistant to mould, rot and vermin, also deters water, weak alkalis, acid, organic solvents and ultraviolet radiation; such features, in addition with fire resistance, thermal isolation and sound absorbency properties, make mineral wool a suitable thermal insulating material for a wide variety of applications (Itewi, 2011& Pfundstein, Gellert, Spitzner, & Rudolphi, 2012). Its use in the construction sector not only decreases the risk of fire, it also results in energy savings, Green House Gases (GHG) emissions and noise pollution along the building's service lifetime.

Rolan rockwool thermal acoustic insulation board is made of mineral fibers bonded with a thermosetting resin. It has application in the construction industry in general. It is installed on walls and roofs in commercial and residential buildings. It does not retain moisture and is also fire resistant.

The standard presentation is in boards of 61 cm (2 ft.) wide and length of 122 cm (4 ft.), thickness of 51 mm (2 in) to 152 mm (6 in). It is designed to provide a thermal resistance "R" from 1.45 to 4.29 m^2 K/W (8-24 $ft.^2$ h ° F / Btu). Figure 1 shows the product and Table 2 shows the values of thermal insulation at 24 °C of average temperature.

Figure 1. Rolan rockwool insulation board.

Table 1. Thermal resistance of Rolan´s mineral wool products at 24°C of average temperature.

THICKNESS		RSI-VALUE
M	In	m^2K/W
0.051	2.0	1.45
0.076	3.0	2.12
0.092	3.63	2.60
0.133	5.20	3.76
0.152	6.0	4.29

1.6 Functional unit

The functional unit (FU) is 1 m^2 of insulation material with thickness that provides an average thermal resistance (RSI) of 1 m^2 K/W in a building with a service life of 60 years. The parameters considered were:

- Lambda (d) =0.03676 W/mK
- Density = 38.5 kg/m^3
- Weight = 1.4153 kg

2 Content declaration

This section presents the relevant materials and chemical substances of Rolan rockwool insulation board. Table 2 presents the formula, function, description, relative weight, CAS number and EC numbers of the product´s content and also shows this substances are not listed in the "Candidate List of Substances of Very High Concern" (SVHC), this list includes 144 substances.

Some substances from the candidate list will be prioritized for authorization and be included in "SVHC authorization list" those substances will not be allowed to be used, placed on the market or imported into the EU after a date to be set unless the company is granted an authorization. The updated list at April 2013 contains 22 substances on SVHC authorization (CIRS, 2012).

Substances of very high concern (SVHC) under the European Union regulation for the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) are identified as substances that may have serious and often irreversible effects on human health and the environment (ECHA, 2013).

CIRS (2012) considers SVHC as those substances which are: carcinogenic, mutagenic or toxic to reproduction (CMRs); persistent, bio-accumulative and toxic (PBTs); very persistent and bio-accumulative (vPvBs); seriously and / or irreversibly damaging the environment or human health, as substances damaging the hormone system.

Table 2. Product content declaration.

Substances	Formula	Function	Description	Relative Weight %	CAS No.	EC/LIST No.	SVHC
Urea	CH_4N_2O	Additive	Stabilizer	1.44	57-13-6	200-315-5	Not listed
Phenolic resin:	-----------	Binder	-----------	5.44	Mix:	--------------	Not listed
Formaldehyde	CH_2O	-----------	Intermediate in production of phenolic resins	0.46	50-00-0	200-001-8	Not listed
Phenol	C_6H_6O	-----------		0.08	108-95-2	203-632-7	Not listed
Slags	-----------	Main raw material	Basic Oxygen furnace Slag (converter slag)	79.46	91722-09-7	294-409-3	Not listed
Basalt	-----------	Main raw material	Basalt (Innocuous silicates, glass and minor metal oxides)	13.66	14808-60-7	--------------	Not listed
Silane	H_4Si	Additive	Pyrophoric compressed gas	1.27E-13	7803-62-5	232-263-4	Not listed

3 Environmental performance related information

This declaration is an environmental product declaration in accordance with International EPD® System. It presents the environmental performance of the Rolan rockwool insulation board in an objective and standardized way.

The results of the Life Cycle Assessment (LCA) study of the rock wool insulation board are presented for each life cycle stage.

3.1 Evaluation method

The LCA was carried out according to the Product Category Rules (PCR) 2012.01 version 1.2 for Construction Products and CPC (Central Product Classification) 54 Construction Services.

According to the UN CPC classifications system, Rolan rockwool insulation board has the CPC code 54650, which categorize the product in section 5, as a construction product, within the subclass 650 for insulation services.

3.2 Functional and declared unit

The functional unit is 1 m^2 of insulation material with a thickness that provides a design thermal resistance R = 1 and with an expected average service life of 60 years. The unit for the functional unit is kg.

The functional unit (FU) is 1 m^2 of insulation material with thickness that provides an average thermal resistance (RSI) of 1 m^2K/W in a building with a service life of 60 years.

3.3 System boundaries

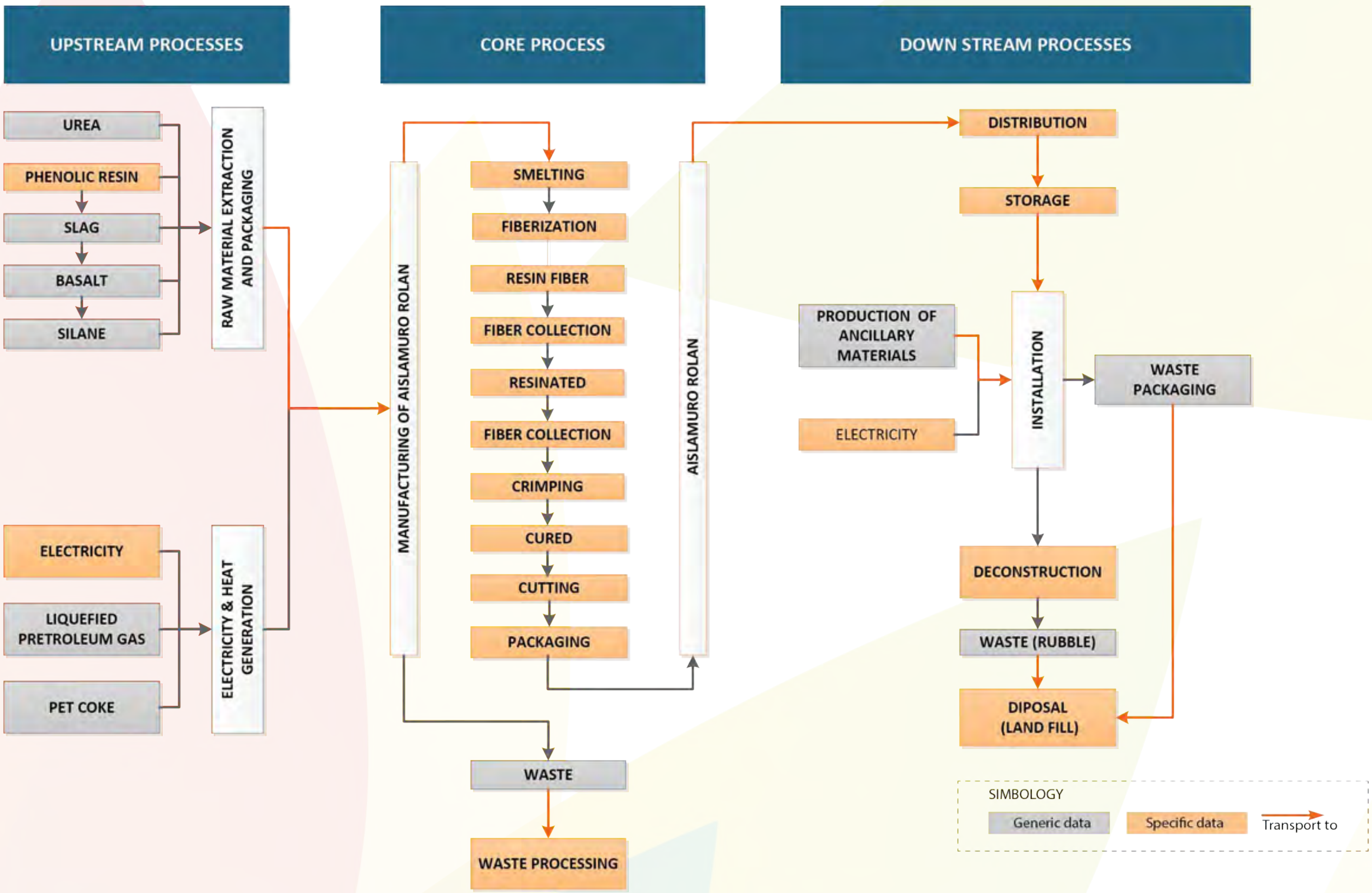
The system boundary defined for this EPD was a cradle to gate with options. During the life cycle of Rolan rockwool insulation board the Upstream, Core and Downstream modules were considered agreeing with General Program Instructions (GPI) as described in Table 3.

Table 3. The life cycle of Rolan rockwool insulation board divided into three process modules according to GPI.

GPI Modules		Life cycle stages	Module Information
UPSTREAM	PRODUCT STAGE	A1. Raw Material Supply	• Extraction and processing of raw materials. • Electricity, steam and heat generation from primary energy resources, including their extraction, refining and transport. • Packaging of raw materials.
UPSTREAM	PRODUCT STAGE	A2. Transport	• Average transport of raw and packaging materials for building product, as well fuels, from the gate of supplier's plant to Rolan´s production site gate.
CORE	PRODUCT STAGE	A3 Manufacturing	• Manufacturing and packaging of building product. • Treatment of waste generated from the manufacturing processes (packaging and oil).
DOWNSTREAM	CONSTRUCCION PROCESS	A4. Transport	• Transport of building product from manufacturer to storage. • Transport of building product from storage to building site.
DOWNSTREAM	CONSTRUCCION PROCESS	A5. Installation process	• Installation of the product at the building site. • Production and transportation of ancillary materials. • Energy required for the installation. • Disposal of the waste from product packaging.
DOWNSTREAM		B1. Material emission from usage*	• Rolan rockwool insulation board does not record emissions during this stage.
DOWNSTREAM		B2. Usage stage *	• The usage stage does not require consumption of materials and energy.
DOWNSTREAM		B3. Maintenance*	• Rolan rockwool insulation board does not require maintenance throughout its service life.
DOWNSTREAM		B5. Repair*	• It was assumed that there was no damage to the walls during the product service life, thus no repairs were considered.
DOWNSTREAM		B4. Replacement*	• Rolan rockwool does not require replacement during the services life of the building.
DOWNSTREAM		B5. Refurbishment*	• It was not considered any remodeling to the building.
DOWNSTREAM	END OF LIFE	C1.Deconstruction	• Dismantling or demolition of the product from the construction, including initial on-site sorting of the materials.
DOWNSTREAM	END OF LIFE	C2. Transport	• Transportation of the discarded product accounts for part of the waste processing, e.g. to a recycling site and transportation of waste e.g. to final sorting yard or disposal.
DOWNSTREAM	END OF LIFE	C3. Waste processing	• Collection of waste fractions from the deconstruction and waste processing of material flows intended for reuse, recycling and energy recovery. • Materials for recycling or energy recovery processing
DOWNSTREAM	END OF LIFE	C4. Disposal	• Transport from construction site to landfill • Waste disposal

According to manufacturer, Rolan rockwool insulation board does not require maintenance or replacements during the reference service life in the building (60 years). Thus stages from B1 to B5 were not considered.

Figure 2. System boundaries.



3.4 Cut-off and allocation principles

Air emissions, water discharges and solid waste were allocated considering the production rates, all unit processes were considered, thus no cut off principles were applied.

3.5 Data quality

Table 4. Data quality aspects.

Time-related coverage	Data collected are representative of 2012
Geographical coverage	Most data was collected from sources in Mexico. Some data unit processes from international producers was collected or adapted.
Technology coverage	An average technology mix was considered
Precision	For most unit processes a weighted average was calculated
Completeness	All the relevant information and data needed for interpretation was available and complete.
Representativeness	Data reflects the overall situation of rock wool panels in Mexico. Data collection considers geographic situation and Mexican context along life cycle stages.
Consistency	The LCA methodology was applied consistently in all phases of the study, also assumptions and calculations were consistent.
Sources of the data	Different data sources were used: for specific data the company provides information of the process, average from a specific process and also averages from main suppliers. Regarding to generic data previous LCA information and Ecoinvent 2.0 data base were used.

3.6 Environmental profile of the product

3.6.1 Use of resources

Table 5 show total consumption of resources, the data describes the consumption under four categories: renewable primary energy resources, non-renewable primary energy resources, secondary material and net fresh water. The results are reported for each life stage process modules, as required for the EPD system according to the General Program Instructions (GPI): core, upstream and downstream modules.

Table 5. Total consumption of resources associated to the production of Rolan rockwool insulation board.

Parameter	Unit	Upstream Processes	Core Processes	Downstream Processes	
Total use of renewable primary energy resources					
Fossil	MJ	43.9797	3.4170	77.1437	**124.5404**
Nuclear	MJ	1.1730	0.3051	6.6465	**8.1246**
Biomass	MJ	5.30E-05	1.01E-05	7.27E-05	**1.36E-04**
Total use of non- renewable primary energy resources					
Biomass	MJ	0.1212	0.0088	0.4862	**0.6163**
Wind, solar, geothermal	MJ	0.0132	0.0030	0.1107	**0.1270**
Water	MJ	0.2091	0.0563	1.9105	**2.1760**
Use of secondary material	kg	0	0	1.7700	**1.7700**
Use of net fresh water	m^3	0.0054	0.0053	0.0439	**0.0546**

3.6.2 Potential environmental impact

Table 6 indicates the potential environmental impacts of Rolan rockwool insulation board according to the requirements of the selected PCR. The environmental impact categories were analyzed using the Impact Assessment Method CML 2001 (baseline) the results are indicated referred to core, upstream and downstream modules and Figure 3 shows the contribution of each process module to the potential environmental impact.

Table 6. Potential environmental impact of the production of Rolan rockwool insulation board by process module.

Impact category	Unit	Upstream Processes	Core Processes	Downstream Processes	Total
Abiotic depletion potential (ADP)	kg Sb eq	0.0207	0.0016	0.0462	**0.0685**
Acidification potential (AP)	kg SO_2 eq	0.0086	0.0087	0.0282	**0.0455**
Eutrophication potential (EP)	kg PO_4 eq	0.0007	0.0020	0.0043	**0.0070**
Global warming (GWP)	kg CO_2 eq	0.9436	0.2363	5.4162	**6.5961**
Ozone layer depletion (ODP)	kg CFC-11 eq	3.04E-07	0.0000	0.0000	**0.0000**
Photochemical oxidation (POCP)	kg C_2H_4	0.0005	0.0001	0.0026	**0.0032**

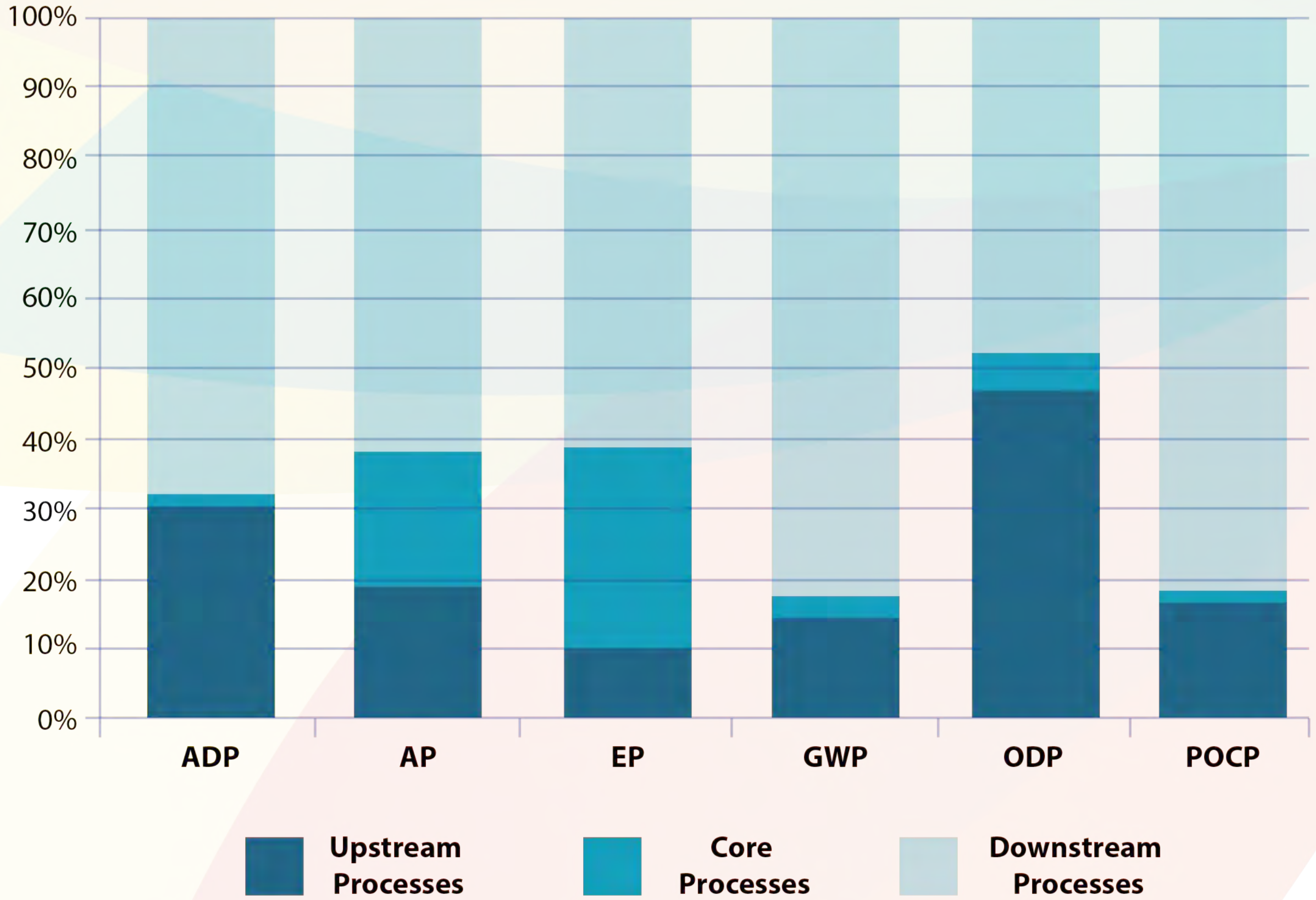


Figure 3 Contribution of each process module to the potential environmental impact.

4 Additional information

4.1 Waste generation

Table 7 shows the amount of waste generated by Rolan rockwool insulation board.

Table 7. Total production of hazardous and nonhazardous waste generated for the production of Rolan rockwool insulation board.

Type of waste	Upstream Processes	Core Processes	Downstream Processes	Total
Hazardous waste (kg)	2.17E-04	0.0000	0.0013	**0.0016**
Non-hazardous waste (kg)	0.1066	0.0220	18.4491	**18.5776**

4.2 Work practices

This section contains the recommended work practices applicable to all that work with fiber glass, rock wool and slag wool products, products that are made from synthetic Vitreous Fibers (SVF). Since Rolan rockwool insulation board fits into this category thse guidelines apply for all activities related to its handling, installation and disposal.

This safe work practices were taken from the "product stewardship program" of the trade association of North American manufacturers of fiber glass, rock wool and slag wool insulation products (NAIMA,2014), association to which Aislantes Minerales S.A. de C.V. is an active member.

Scientific evidence demonstrates that rock and slag wool are safe to manufacture, install and use when recommended work practices are followed.

Minimize Dust Generation:

- Keep the material in its packaging as long as practical and if possible.
- Tools that generate the least amount of dust should be used. If power tools are to be used, they should be equipped with appropriate dust collection systems as necessary.
- Keep work areas clean and free of scrap SVF material.
- Do not use compressed air for cleanup unless there is no other effective method. If compressed air must be used, proper procedures and control measures must be implemented.
- Where repair or maintenance of equipment that is either insulated with SVF or covered with settled SVF dust is necessary, clean the equipment first with high-efficiency particulate absorption (HEPA) vacuum equipment or equivalent or wipe the surface clean with a wet rag to remove excess dust and loose fibers.
- Avoid unnecessary handling of scrap materials by placing them in waste disposal containers and keep equipment as close to working.

Maintain Adequate Ventilation:

Unless other proper procedures and control measures have been implemented, the next measures should be taken:

- The use of dust collection systems in manufacturing and fabrication settings where appropriate and feasible.

- The filtration of exhausted air containing SVFs prior to recirculation into interior workspaces.

- The regularly revision and maintenance of f ventilation systems if they are used to capture SVFs.

Wear Appropriate Clothing:

Skin irritation is avoided if the skin is protected of the contact of SVF.

During the handling of insulation board is recommended the use of:

- Loose-fitting, long-sleeved and long-legged clothing. Remove SVF dust from the work clothes before leaving work.

- Head cover, especially when working with material overhead.

- Gloves

Wear Appropriate Personal Protective Equipment:

Personal protective equipment measures will be dictated by the work environment and may include:

- Respiratory protective equipment it is recommended that workers wear a NIOSH certified dust respirator (certified N95 or greater) when removing SVF products during significant repair or demolition activity or whenever expo sures on a job exceed the 1 f/cc 8-hour time weighted average (TWA) permissible exposure limit.
  1 f/cc = 1 Fiber per Cubic Centimeter.

- Eye protection.

- The appropriate personal protective equipment should be properly fitted and worn.

Removal of Fibers from the Skin and Eyes:

- Fibers accumulate on the skin: do not rub or scratch. Never remove fibers by blowing with compressed air.

- Fibers penetrating the skin. Removed by applying and then removing adhesive tape so that the fibers adhere to the tape and are pulled out of the skin.

- Fibers deposited in the eye. Do not rub the eyes. Flush them with water or eyewash solution (if available). Consult a physician if the irritation persists.

5 Information about the organization and the verifier

EPD Programe:	Additional information about the International EPD system and PCR for the assessment of the environmental performance of products is available on the internet site of the Swedish Environmental Management Council at www.environdec.com
PCR base document:	Construction products and CPC 54 construction services, version 1.2.
Registration no:	S-P-00532
EPD validity:	3 years
EPD valid within the following geographical area:	Worldwide
PCR review conducted by:	IVL Swedish Environmental Research Institute Ltd. Martin Erlandsson E-mail:martin.erlandsson@ivl.se
Independent verification of the declaration and data, according to ISO 14025:	☐ Internal / ☒ External / ☐ EPD process certification Marcus Wendin Miljögiraff E-mail: Marcus@miljogiraff.se Web page:www.miljogiraff.se Mobile: +46-733-248185 c/o Lusthuset, Södra Larmgatan 6, 411 16 Göteborg, Sweden

For further information about the product and the company please contact to:
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The LCA study and the present EPD have been developed by the
Center for Life Cycle Assessment and Sustainable Design (CADIS), www.centroacv.mx

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7 Glossary

European Commission number

Is a unique seven-digit identifier that is assigned to chemical substances for regulatory purposes within the European Union.

CAS number

The most authoritative collection of disclosed chemical substance information, containing more than 74 million organic and inorganic substances and 64 million sequences. CAS Number is a numeric identifier that can contain up to 10 digits, divided by hyphens into three parts.

Abiotic resources

Natural resources (including energy resources) such as iron ore, crude oil and wind energy, which are regarded as non-living.

Abiotic depletion potential

The decrease of availability of the total reserve of potential functions of abiotic resources, due to the use beyond their rate of replacement. This impact category considers the effect on both renewable and non-renewable resources (JRC-IES, 2010).

In Guinee et al. (2002) ADP is the depletion of minerals and fossil fuels falls within the category non-renewable resources, while extraction of water, wind (abiotic) and wood (biotic) falls within renewable resources are expressed in kg of antimony (Sb) equivalents.

Acidification potential

This impact category addresses the impacts from acidification generated by the emission of airborne acidifying chemicals. Acidification refers literally to processes that increase the acidity of water and soil systems by hydrogen ion concentration. It is caused by atmospheric deposition of acidifying substances generated largely from emissions of nitrogen oxides (NO_x), sulphur dioxide (SO_2) and ammonia (NH_3), the latter contributing to acidification after it is nitrified (in the soil).

Unit of indicator result is kg SO_2 equivalents.

Eutrophication

For Guinee et al. (2002) eutrophication covers all potential impacts of excessively high environmental levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In addition, high nutrient concentrations may also render surface waters unacceptable as a source of drinking water. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition (measured as BOD, biological oxygen demand). As emissions of degradable organic matter have a similar impact, such emissions are also treated under the impact category "eutrophication" which is expressed in kg of PO_4^{3-} equivalents.

Climate change

Is defined as the impact of human emissions on the radiative forcing (i.e. heat radiation absorption) of the atmosphere. This may in turn have adverse impacts on ecosystem health, human health and material welfare. Most of these emissions enhance radiative forcing, causing the temperature at the earth's surface to rise. This is popularly referred to as the 'greenhouse effect' (Guinee et al. 2002).

Global warming potential

Is an index that attempts to integrate the overall climate impacts of a specific action (e.g., emissions of CH_4, NOx or aerosols). It relates the impact of emissions of a gas to that of emission of an equivalent mass of CO_2. The duration of the perturbation is included by integrating radiative forcing over a time horizon (e.g., standard horizons for IPCC have been 20, 100, and 500 years). The time horizon thus includes the cumulative climate change and the decay of the perturbation.

To compare the impacts of emissions of different greenhouse gases, each has been assigned a so- called Global Warming Potential (GWP) index, expressing the ratio between the increased infrared absorption due to the instantaneous emission of 1 kg of the substance and that due to an equal emission of carbon dioxide both integrated over time (Guinee et al. 2002).

Ozone layer depletion

Stratospheric ozone depletion refers to the thinning of the stratospheric ozone layer as a result of anthropogenic emissions. This causes a greater fraction of solar UV-B radiation to reach the earth's surface, with potentially harmful impacts on human health, animal health, terrestrial and aquatic ecosystems, biochemical cycles and materials. This impact category is expressed as Kg of CFC-11 equivalents.

Photochemical oxidation

Photo-oxidant formation is the formation of reactive chemical compounds such as ozone by the action of sunlight on certain primary air pollutants. These reactive compounds may be injurious to human health and ecosystems and may also damage crops. Photo-oxidants may be formed in the troposphere under the influence of ultraviolet light, through photochemical oxidation of Volatile Organic Compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NOx). Ozone is considered the most important of these oxidizing compounds, along with peroxyacetylnitrate (PAN). The units in which is expressed this impact category is in kg of ethylene equivalents (Guinee et al. 2002).

Rolan

EPD®

CML-IA baseline V3.00

CML-IA is a LCA methodology developed by the Center of Environmental Science (CML) of Leiden University in The Netherlands.
More information on: http://cml.leiden.edu/software/data-cmlia.html

This method is an update of the CML 2 baseline 2000 and released by CML in April 2013 (version 4.2). The CML 2 baseline 2000 version can be found in the 'superseded' list. For most impact categories, substances have been added and removed and/or characterisation factors were updated, according to new scientific insight. Only the impact category Photochemical oxidation did not undergo any changes.

The CML-IA (baseline) method elaborates the problem-oriented (midpoint) approach. The CML Guide provides a list of impact assessment categories grouped into:

A: Obligatory impact categories (Category indicators used in most LCAs)
B: Additional impact categories (operational indicators exist, but are not often included in LCA studies)
C: Other impact categories (no operational indicators available, therefore impossible to include quantitatively in LCA)

In case several methods are available for obligatory impact categories a baseline indicator is selected, based on the principle of best available practice. These baseline indicators are category indicators at "mid-point level" (problem oriented approach)". Baseline indicators are recommended for simplified studies. The guide provides guidelines for inclusion of other methods and impact category indicators in case of detailed studies and extended studies.
Only baseline indicators are available in the CML method in SimaPro (based on CML Excel spreadsheet with characterisation and normalisation factors). In general, these indicators do not deviate from the ones in the spreadsheet. In case the spreadsheet contained synonyms of substance names already available in the substance list of the SimaPro database, the existing names are used. A distinction is made for emissions to agricultural soil and industrial soil. Emissions to agricultural soil are made clear by placing 'agricultural' in the column 'subcompartment' while emissions to industrial soil are blank. Emissions to seawater are indicated with 'ocean', while emissions to fresh water are blank (we assume that all emissions to water in existing process records are emissions to fresh water).

Depletion of abiotic resources
Two impact categories: Abiotic depletion (elements, ultimate reserves) and abiotic depletion (fossil fuels)
Abiotic depletion (elements, ultimate reserves) is related to extraction of minerals due to inputs in the system. The Abiotic Depletion Factor (ADF) is determined for each extraction of minerals (kg antimony equivalents/kg extraction) based on concentration reserves and rate of deaccumulation. Abiotic depletion of fossil fuels is related to the Lower Heating Value (LHV) expressed in MJ per kg of m3 fossil fuel. The reason for taking the LHV is that fossil fuels are considered to be fully substitutable.

Global warming
The characterisation model as developed by the Intergovernmental Panel on Climate Change (IPCC) is selected for development of characterisation factors. Factors are expressed as Global Warming Potential for time horizon 100 years (GWP100), in kg carbon dioxide equivalent/kg emission.

Ozone layer depletion (steady state)
The characterisation model is developed by the World Meteorological Organisation (WMO) and defines ozone depletion potential of different gases (kg CFC-11 equivalent/ kg emission).

Human toxicity (HTP inf), Freshwater aquatic ecotoxicity (FAETP inf), Marine aquatic ecotoxicology (MAETP inf) and Terrestrial ecotoxicity (TETP inf)
Characterisation factors, expressed as Human Toxicity Potentials (HTP), are calculated with USES-LCA, describing fate, exposure and effects of toxic substances for an infinite time horizon. For each toxic substance HTP's are expressed as 1,4-dichlorobenzene equivalents/ kg emission.

Photochemical oxidation (high NOx)
The model is developed by Jenkin & Hayman and Derwent and defines photochemical oxidation expressed in kg ethylene equivalents per kg emission.

Acidification (incl. fate, average Europe total, A&B)
Acifidication potential expressed in kg SO2 equivalents per kg emission. Model is developed by Huijbregts.

Eutrophication (fate not included)
Eutrophication potential developed by Heijungs et al and expressed in kg PO4 equivalents per kg emission.

For further information see the database manual.

Some of the original names were abbreviated or changed to be clearer to the user:

Abiotic depletion (elements, ultimate reserves) is abreviated to Abiotic depletion
Acidification (incl.fate, average Europe total, A&B), renamed in Acidification
Eutrophication (incl. fate, average Europe total, A&B), renamed in Eutrophication (incl. fate)
Global warming (GWP 100), renamed to Global warming (GWP 100 a)
Ozone layer depletion (ODP steady state), renamed to Ozone layer depletion (ODP)
Human toxicity (HTP inf.), renamed to Human toxicity
Fresh water aquatic ecotoxicity (FAETP inf.), renamed to Fresh water aquatic ecotoxicity
Marina aquatic ecotoxicity (MAETP inf.), renamed to Marine aquatic ecotoxicity
Terrestrial ecotoxicity (TETP inf.), renamed to Terrestrial ecotoxicity
Photochemical oxidation (high NOx), renamed to Photochemical oxidation

All adaptions of the method (2001 - 2012) are present in CML-IA_update_info.xls which can be downloaded from the CML website http://cml.leiden.edu/software/data-cmlia.html

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Other adaptations (October 2013, version 3.0)
- Characterisation factors for methane, biogenic was added to the impact category Global warming 100a: 22,25 kg CO2 eq./kg.
- Mecoprop (CAS 93-65-2) was added with the same characterisation factor as its synonym 2-(4-Chloro-2-methylphenoxy)propanoic acid (CAS 7085-19-0). These substances have different characterisation factors in USEtox and ILCD method. This problem is not solved yet by the developers of those methods.
- The substance "Phoshorus, total" was added to the impact category "Eutrophication".
- Added mineral resource flow synonyms.

Impact category	Global warming (GWP100a)	kg CO2 eq		
Air	(unspecified)	1-Propanol, 3,3,3-trifluoro-2,2-bis(trifluoromethyl)-, HFE-7100	297	kg CO2 eq / kg
Air	(unspecified)	Butane, perfluoro-	8860	kg CO2 eq / kg
Air	(unspecified)	Butane, perfluorocyclo-, PFC-318	10300	kg CO2 eq / kg
Air	(unspecified)	Carbon dioxide	1	kg CO2 eq / kg
Air	(unspecified)	Carbon dioxide, fossil	1	kg CO2 eq / kg
Air	(unspecified)	Carbon dioxide, land transformation	1	kg CO2 eq / kg
Air	(unspecified)	Cis-perfluorodecalin	7500	kg CO2 eq / kg
Air	(unspecified)	Dinitrogen monoxide	298	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1-chloro-1,1-difluoro-, HCFC-142b	2310	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1-chloro-2,2,2-trifluoro-(difluoromethoxy)-, HCFE-235da2	350	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	725	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,1-difluoro-, HFC-152a	124	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	146	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,1,1-trifluoro-, HFC-143a	4470	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1430	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	6130	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,2-dibromotetrafluoro-, Halon 2402	1640	kg CO2 eq / kg
Air	(unspecified)	Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	10000	kg CO2 eq / kg
Air	(unspecified)	Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	609	kg CO2 eq / kg
Air	(unspecified)	Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	77	kg CO2 eq / kg
Air	(unspecified)	Ethane, chloropentafluoro-, CFC-115	7370	kg CO2 eq / kg
Air	(unspecified)	Ethane, hexafluoro-, HFC-116	12200	kg CO2 eq / kg
Air	(unspecified)	Ethane, pentafluoro-, HFC-125	3500	kg CO2 eq / kg
Air	(unspecified)	Ether, 1,1,1-trifluoromethyl methyl-, HFE-143a	756	kg CO2 eq / kg
Air	(unspecified)	Ether, 1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl-, HFE-347mcc3	575	kg CO2 eq / kg
Air	(unspecified)	Ether, 1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl-, HFE-347pcf2	580	kg CO2 eq / kg
Air	(unspecified)	Ether, 1,1,2,2-Tetrafluoroethyl methyl-, HFE-254cb2	359	kg CO2 eq / kg
Air	(unspecified)	Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-, HFE-356pcc3	110	kg CO2 eq / kg
Air	(unspecified)	Ether, di(difluoromethyl), HFE-134	6320	kg CO2 eq / kg
Air	(unspecified)	Ether, difluoromethyl 2,2,2-trifluoroethyl-, HFE-245cb2	708	kg CO2 eq / kg
Air	(unspecified)	Ether, difluoromethyl 2,2,2-trifluoroethyl-, HFE-245fa2	659	kg CO2 eq / kg
Air	(unspecified)	Ether, nonafluorobutane ethyl-, HFE569sf2 (HFE-7200)	59	kg CO2 eq / kg
Air	(unspecified)	Ether, pentafluoromethyl-, HFE-125	14900	kg CO2 eq / kg
Air	(unspecified)	Hexane, perfluoro-	9300	kg CO2 eq / kg
Air	(unspecified)	HFE-236ca12 (HG-10)	2800	kg CO2 eq / kg
Air	(unspecified)	HFE-338pcc13 (HG-01)	1500	kg CO2 eq / kg
Air	(unspecified)	HFE-43-10pccc124 (H-Galden1040x)	1870	kg CO2 eq / kg
Air	(unspecified)	Methane	25	kg CO2 eq / kg
Air	(unspecified)	Methane, biogenic	22,25	kg CO2 eq / kg
Air	(unspecified)	Methane, bromo-, Halon 1001	5	kg CO2 eq / kg
Air	(unspecified)	Methane, bromochlorodifluoro-, Halon 1211	1890	kg CO2 eq / kg
Air	(unspecified)	Methane, bromotrifluoro-, Halon 1301	7140	kg CO2 eq / kg
Air	(unspecified)	Methane, chlorodifluoro-, HCFC-22	1810	kg CO2 eq / kg
Air	(unspecified)	Methane, chlorotrifluoro-, CFC-13	14400	kg CO2 eq / kg
Air	(unspecified)	Methane, dichloro-, HCC-30	8,7	kg CO2 eq / kg
Air	(unspecified)	Methane, dichlorodifluoro-, CFC-12	10900	kg CO2 eq / kg
Air	(unspecified)	Methane, difluoro-, HFC-32	675	kg CO2 eq / kg
Air	(unspecified)	Methane, fossil	25	kg CO2 eq / kg
Air	(unspecified)	Methane, monochloro-, R-40	13	kg CO2 eq / kg
Air	(unspecified)	Methane, tetrachloro-, CFC-10	1400	kg CO2 eq / kg
Air	(unspecified)	Methane, tetrafluoro-, CFC-14	7390	kg CO2 eq / kg
Air	(unspecified)	Methane, trichlorofluoro-, CFC-11	4750	kg CO2 eq / kg
Air	(unspecified)	Methane, trifluoro-, HFC-23	14800	kg CO2 eq / kg
Air	(unspecified)	Nitrogen fluoride	17200	kg CO2 eq / kg
Air	(unspecified)	Pentane, 2,3-dihydroperfluoro-, HFC-4310mee	1640	kg CO2 eq / kg
Air	(unspecified)	Pentane, dodecafluoro-, PFC-4-1-12	9160	kg CO2 eq / kg
Air	(unspecified)	PFPMIE	10300	kg CO2 eq / kg
Air	(unspecified)	Propane, 1,1,1,2,3,3,3-heptafluoro-, HFC-227ea	3220	kg CO2 eq / kg
Air	(unspecified)	Propane, 1,1,1,3,3-pentafluoro-, HFC-245fa	1030	kg CO2 eq / kg
Air	(unspecified)	Propane, 1,1,1,3,3,3-hexafluoro-, HCFC-236fa	9810	kg CO2 eq / kg
Air	(unspecified)	Propane, 1,3-dichloro-1,1,2,2,3-pentafluoro-, HCFC-225cb	595	kg CO2 eq / kg
Air	(unspecified)	Propane, 3,3-dichloro-1,1,1,2,2-pentafluoro-, HCFC-225ca	122	kg CO2 eq / kg
Air	(unspecified)	Propane, perfluoro-	8830	kg CO2 eq / kg
Air	(unspecified)	Sulfur hexafluoride	22800	kg CO2 eq / kg
Air	(unspecified)	Trifluoromethylsulfur pentafluoride	17700	kg CO2 eq / kg

Impact category	Human toxicity	kg 1,4-DB eq		
Air	(unspecified)	2-(4-Chloro-2-methylphenoxy)propanoic acid	119	kg 1,4-DB eq / kg
Water	(unspecified)	2-(4-Chloro-2-methylphenoxy)propanoic acid	205	kg 1,4-DB eq / kg
Water	ocean	2-(4-Chloro-2-methylphenoxy)propanoic acid	0,843	kg 1,4-DB eq / kg
Soil	(unspecified)	2-(4-Chloro-2-methylphenoxy)propanoic acid	42,4	kg 1,4-DB eq / kg
Soil	agricultural	2-(4-Chloro-2-methylphenoxy)propanoic acid	744	kg 1,4-DB eq / kg
Air	(unspecified)	2-Methyl-4-chlorophenoxyacetic acid	14,7	kg 1,4-DB eq / kg
Water	(unspecified)	2-Methyl-4-chlorophenoxyacetic acid	15,1	kg 1,4-DB eq / kg
Water	ocean	2-Methyl-4-chlorophenoxyacetic acid	0,0369	kg 1,4-DB eq / kg
Soil	(unspecified)	2-Methyl-4-chlorophenoxyacetic acid	0,972	kg 1,4-DB eq / kg
Soil	agricultural	2-Methyl-4-chlorophenoxyacetic acid	104	kg 1,4-DB eq / kg
Air	(unspecified)	2,4-D	6,64	kg 1,4-DB eq / kg
Water	(unspecified)	2,4-D	3,47	kg 1,4-DB eq / kg
Water	ocean	2,4-D	0,0000668	kg 1,4-DB eq / kg
Soil	(unspecified)	2,4-D	0,722	kg 1,4-DB eq / kg
Soil	agricultural	2,4-D	47	kg 1,4-DB eq / kg
Air	(unspecified)	2,4,5-T	0,887	kg 1,4-DB eq / kg
Water	(unspecified)	2,4,5-T	1,93	kg 1,4-DB eq / kg
Water	ocean	2,4,5-T	0,0054	kg 1,4-DB eq / kg

Soil	(unspecified)	2,4,5-T	0,177	kg 1,4-DB eq / kg
Soil	agricultural	2,4,5-T	5,84	kg 1,4-DB eq / kg
Air	(unspecified)	Acephate	3,06	kg 1,4-DB eq / kg
Water	(unspecified)	Acephate	2,11	kg 1,4-DB eq / kg
Water	ocean	Acephate	0,00051	kg 1,4-DB eq / kg
Soil	(unspecified)	Acephate	0,307	kg 1,4-DB eq / kg
Soil	agricultural	Acephate	21,6	kg 1,4-DB eq / kg
Air	(unspecified)	Acrolein	56,9	kg 1,4-DB eq / kg
Water	(unspecified)	Acrolein	58,6	kg 1,4-DB eq / kg
Water	ocean	Acrolein	0,803	kg 1,4-DB eq / kg
Soil	(unspecified)	Acrolein	16,6	kg 1,4-DB eq / kg
Soil	agricultural	Acrolein	234	kg 1,4-DB eq / kg
Air	(unspecified)	Acrylonitrile	3350	kg 1,4-DB eq / kg
Water	(unspecified)	Acrylonitrile	7070	kg 1,4-DB eq / kg
Water	ocean	Acrylonitrile	50,9	kg 1,4-DB eq / kg
Soil	(unspecified)	Acrylonitrile	1520	kg 1,4-DB eq / kg
Soil	agricultural	Acrylonitrile	488000	kg 1,4-DB eq / kg
Air	(unspecified)	Aldicarb	71,6	kg 1,4-DB eq / kg
Water	(unspecified)	Aldicarb	60,7	kg 1,4-DB eq / kg
Water	ocean	Aldicarb	0,239	kg 1,4-DB eq / kg
Soil	(unspecified)	Aldicarb	13,4	kg 1,4-DB eq / kg
Soil	agricultural	Aldicarb	507	kg 1,4-DB eq / kg
Air	(unspecified)	Aldrin	19,3	kg 1,4-DB eq / kg
Water	(unspecified)	Aldrin	5980	kg 1,4-DB eq / kg
Water	ocean	Aldrin	779	kg 1,4-DB eq / kg
Soil	(unspecified)	Aldrin	158	kg 1,4-DB eq / kg
Soil	agricultural	Aldrin	4670	kg 1,4-DB eq / kg
Air	(unspecified)	Ammonia	0,1	kg 1,4-DB eq / kg
Air	(unspecified)	Anilazine	0,0716	kg 1,4-DB eq / kg
Water	(unspecified)	Anilazine	0,235	kg 1,4-DB eq / kg
Water	ocean	Anilazine	0,000818	kg 1,4-DB eq / kg
Soil	(unspecified)	Anilazine	0,000301	kg 1,4-DB eq / kg
Soil	agricultural	Anilazine	0,0801	kg 1,4-DB eq / kg
Air	(unspecified)	Aniline, 3,4-dichloro-	215	kg 1,4-DB eq / kg
Water	(unspecified)	Aniline, 3,4-dichloro-	134	kg 1,4-DB eq / kg
Water	ocean	Aniline, 3,4-dichloro-	1,51	kg 1,4-DB eq / kg
Soil	(unspecified)	Aniline, 3,4-dichloro-	30,6	kg 1,4-DB eq / kg
Soil	agricultural	Aniline, 3,4-dichloro-	1680	kg 1,4-DB eq / kg
Air	(unspecified)	Aniline, m-chloro-	17000	kg 1,4-DB eq / kg
Water	(unspecified)	Aniline, m-chloro-	3520	kg 1,4-DB eq / kg
Water	ocean	Aniline, m-chloro-	2,06	kg 1,4-DB eq / kg
Soil	(unspecified)	Aniline, m-chloro-	463	kg 1,4-DB eq / kg
Soil	agricultural	Aniline, m-chloro-	29900	kg 1,4-DB eq / kg
Air	(unspecified)	Aniline, p-chloro-	262	kg 1,4-DB eq / kg
Water	(unspecified)	Aniline, p-chloro-	2850	kg 1,4-DB eq / kg
Water	ocean	Aniline, p-chloro-	4,03	kg 1,4-DB eq / kg
Soil	(unspecified)	Aniline, p-chloro-	510	kg 1,4-DB eq / kg
Soil	agricultural	Aniline, p-chloro-	34700	kg 1,4-DB eq / kg
Air	(unspecified)	Anthracene	0,52	kg 1,4-DB eq / kg
Water	(unspecified)	Anthracene	2,06	kg 1,4-DB eq / kg
Water	ocean	Anthracene	0,157	kg 1,4-DB eq / kg
Soil	(unspecified)	Anthracene	0,0198	kg 1,4-DB eq / kg
Soil	agricultural	Anthracene	0,515	kg 1,4-DB eq / kg
Air	(unspecified)	Antimony	6710	kg 1,4-DB eq / kg
Water	(unspecified)	Antimony	5140	kg 1,4-DB eq / kg
Water	ocean	Antimony	8640	kg 1,4-DB eq / kg
Soil	(unspecified)	Antimony	2630	kg 1,4-DB eq / kg
Soil	agricultural	Antimony	8890	kg 1,4-DB eq / kg
Water	(unspecified)	Arsenic	951	kg 1,4-DB eq / kg
Water	ocean	Arsenic	2400	kg 1,4-DB eq / kg
Air	(unspecified)	Arsenic, ion	348000	kg 1,4-DB eq / kg
Soil	(unspecified)	Arsenic, ion	1020	kg 1,4-DB eq / kg
Soil	agricultural	Arsenic, ion	31800	kg 1,4-DB eq / kg
Air	(unspecified)	Atrazine	4,45	kg 1,4-DB eq / kg
Water	(unspecified)	Atrazine	4,56	kg 1,4-DB eq / kg
Water	ocean	Atrazine	0,0176	kg 1,4-DB eq / kg
Soil	(unspecified)	Atrazine	0,876	kg 1,4-DB eq / kg
Soil	agricultural	Atrazine	21,3	kg 1,4-DB eq / kg
Air	(unspecified)	Azinphos-ethyl	203	kg 1,4-DB eq / kg
Water	(unspecified)	Azinphos-ethyl	456	kg 1,4-DB eq / kg
Water	ocean	Azinphos-ethyl	1,6	kg 1,4-DB eq / kg
Soil	(unspecified)	Azinphos-ethyl	6,9	kg 1,4-DB eq / kg
Soil	agricultural	Azinphos-ethyl	765	kg 1,4-DB eq / kg
Air	(unspecified)	Azinphos-methyl	14,3	kg 1,4-DB eq / kg
Water	(unspecified)	Azinphos-methyl	2,5	kg 1,4-DB eq / kg
Water	ocean	Azinphos-methyl	0,0057	kg 1,4-DB eq / kg
Soil	(unspecified)	Azinphos-methyl	0,0992	kg 1,4-DB eq / kg
Soil	agricultural	Azinphos-methyl	39	kg 1,4-DB eq / kg
Air	(unspecified)	Barium	756	kg 1,4-DB eq / kg
Water	(unspecified)	Barium	630	kg 1,4-DB eq / kg
Water	ocean	Barium	805	kg 1,4-DB eq / kg
Soil	(unspecified)	Barium	318	kg 1,4-DB eq / kg
Soil	agricultural	Barium	363	kg 1,4-DB eq / kg
Air	(unspecified)	Benomyl	0,021	kg 1,4-DB eq / kg
Water	(unspecified)	Benomyl	0,142	kg 1,4-DB eq / kg
Water	ocean	Benomyl	0,000242	kg 1,4-DB eq / kg

Soil	(unspecified)	Benomyl	0,00113	kg 1,4-DB eq / kg
Soil	agricultural	Benomyl	0,428	kg 1,4-DB eq / kg
Air	(unspecified)	Bentazone	2,14	kg 1,4-DB eq / kg
Water	(unspecified)	Bentazone	0,733	kg 1,4-DB eq / kg
Water	ocean	Bentazone	0,0022	kg 1,4-DB eq / kg
Soil	(unspecified)	Bentazone	0,16	kg 1,4-DB eq / kg
Soil	agricultural	Bentazone	15,1	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene	1900	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene	1830	kg 1,4-DB eq / kg
Water	ocean	Benzene	210	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene	1610	kg 1,4-DB eq / kg
Soil	agricultural	Benzene	14800	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1-chloro-4-nitro-	1180	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1-chloro-4-nitro-	1710	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1-chloro-4-nitro-	225	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1-chloro-4-nitro-	462	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1-chloro-4-nitro-	22200	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,2-dichloro-	9,06	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,2-dichloro-	8,85	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,2-dichloro-	4,09	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,2-dichloro-	6,89	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,2-dichloro-	7,32	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,2,3-trichloro-	131	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,2,3-trichloro-	135	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,2,3-trichloro-	61,9	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,2,3-trichloro-	54,2	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,2,3-trichloro-	56,4	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,2,3,4-tetrachloro-	50	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,2,3,4-tetrachloro-	156	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,2,3,4-tetrachloro-	29,9	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,2,3,4-tetrachloro-	5,18	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,2,3,4-tetrachloro-	79,7	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,2,3,5-tetrachloro-	46,3	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,2,3,5-tetrachloro-	91,8	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,2,3,5-tetrachloro-	24,6	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,2,3,5-tetrachloro-	13,8	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,2,3,5-tetrachloro-	181	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,2,4-trichloro-	123	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,2,4-trichloro-	123	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,2,4-trichloro-	55,6	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,2,4-trichloro-	43,2	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,2,4-trichloro-	42	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,2,4,5-tetrachloro-	34,5	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,2,4,5-tetrachloro-	180	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,2,4,5-tetrachloro-	30,2	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,2,4,5-tetrachloro-	5,35	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,2,4,5-tetrachloro-	84	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,3-dichloro-	62,1	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,3-dichloro-	74,4	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,3-dichloro-	30,4	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,3-dichloro-	49,6	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,3-dichloro-	247	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,3,5-trichloro-	120	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,3,5-trichloro-	125	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,3,5-trichloro-	53,7	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,3,5-trichloro-	51,7	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,3,5-trichloro-	69,1	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, 1,4-dichloro-	1	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, 1,4-dichloro-	1,06	kg 1,4-DB eq / kg
Water	ocean	Benzene, 1,4-dichloro-	0,474	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, 1,4-dichloro-	0,738	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, 1,4-dichloro-	2,88	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, chloro-	9,23	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, chloro-	9,1	kg 1,4-DB eq / kg
Water	ocean	Benzene, chloro-	5,16	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, chloro-	6,83	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, chloro-	7,06	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, ethyl-	0,973	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, ethyl-	0,827	kg 1,4-DB eq / kg
Water	ocean	Benzene, ethyl-	0,0702	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, ethyl-	0,502	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, ethyl-	0,753	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, hexachloro-	3160000	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, hexachloro-	5650000	kg 1,4-DB eq / kg
Water	ocean	Benzene, hexachloro-	3420000	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, hexachloro-	1320000	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, hexachloro-	32600000	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, pentachloro-	409	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, pentachloro-	1200	kg 1,4-DB eq / kg
Water	ocean	Benzene, pentachloro-	412	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, pentachloro-	144	kg 1,4-DB eq / kg
Soil	agricultural	Benzene, pentachloro-	4460	kg 1,4-DB eq / kg
Air	(unspecified)	Benzene, pentachloronitro-	186	kg 1,4-DB eq / kg
Water	(unspecified)	Benzene, pentachloronitro-	90,5	kg 1,4-DB eq / kg
Water	ocean	Benzene, pentachloronitro-	46,1	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzene, pentachloronitro-	4,34	kg 1,4-DB eq / kg

Soil	agricultural	Benzene, pentachloronitro-	72,5	kg 1,4-DB eq / kg
Air	(unspecified)	Benzyl chloride	3520	kg 1,4-DB eq / kg
Water	(unspecified)	Benzyl chloride	2380	kg 1,4-DB eq / kg
Water	ocean	Benzyl chloride	55	kg 1,4-DB eq / kg
Soil	(unspecified)	Benzyl chloride	487	kg 1,4-DB eq / kg
Soil	agricultural	Benzyl chloride	5530	kg 1,4-DB eq / kg
Air	(unspecified)	Beryllium	227000	kg 1,4-DB eq / kg
Water	(unspecified)	Beryllium	14000	kg 1,4-DB eq / kg
Water	ocean	Beryllium	16200	kg 1,4-DB eq / kg
Soil	(unspecified)	Beryllium	7050	kg 1,4-DB eq / kg
Soil	agricultural	Beryllium	12800	kg 1,4-DB eq / kg
Air	(unspecified)	Bifenthrin	19,4	kg 1,4-DB eq / kg
Water	(unspecified)	Bifenthrin	98,2	kg 1,4-DB eq / kg
Water	ocean	Bifenthrin	0,748	kg 1,4-DB eq / kg
Soil	(unspecified)	Bifenthrin	0,297	kg 1,4-DB eq / kg
Soil	agricultural	Bifenthrin	28,6	kg 1,4-DB eq / kg
Air	(unspecified)	Butadiene	2220	kg 1,4-DB eq / kg
Water	(unspecified)	Butadiene	6990	kg 1,4-DB eq / kg
Water	ocean	Butadiene	445	kg 1,4-DB eq / kg
Soil	(unspecified)	Butadiene	2190	kg 1,4-DB eq / kg
Soil	agricultural	Butadiene	3070	kg 1,4-DB eq / kg
Air	(unspecified)	Butadiene, hexachloro-	79000	kg 1,4-DB eq / kg
Water	(unspecified)	Butadiene, hexachloro-	79500	kg 1,4-DB eq / kg
Water	ocean	Butadiene, hexachloro-	39500	kg 1,4-DB eq / kg
Soil	(unspecified)	Butadiene, hexachloro-	35200	kg 1,4-DB eq / kg
Soil	agricultural	Butadiene, hexachloro-	30000	kg 1,4-DB eq / kg
Water	(unspecified)	Cadmium	22,9	kg 1,4-DB eq / kg
Water	ocean	Cadmium	104	kg 1,4-DB eq / kg
Air	(unspecified)	Cadmium, ion	145000	kg 1,4-DB eq / kg
Soil	(unspecified)	Cadmium, ion	66,7	kg 1,4-DB eq / kg
Soil	agricultural	Cadmium, ion	19600	kg 1,4-DB eq / kg
Air	(unspecified)	Captafol	87	kg 1,4-DB eq / kg
Water	(unspecified)	Captafol	496	kg 1,4-DB eq / kg
Water	ocean	Captafol	9,69	kg 1,4-DB eq / kg
Soil	(unspecified)	Captafol	78,8	kg 1,4-DB eq / kg
Soil	agricultural	Captafol	958	kg 1,4-DB eq / kg
Air	(unspecified)	Captan	0,589	kg 1,4-DB eq / kg
Water	(unspecified)	Captan	0,00529	kg 1,4-DB eq / kg
Water	ocean	Captan	0,00000542	kg 1,4-DB eq / kg
Soil	(unspecified)	Captan	0,000114	kg 1,4-DB eq / kg
Soil	agricultural	Captan	0,0975	kg 1,4-DB eq / kg
Air	(unspecified)	Carbaryl	3,21	kg 1,4-DB eq / kg
Water	(unspecified)	Carbaryl	4,69	kg 1,4-DB eq / kg
Water	ocean	Carbaryl	0,00187	kg 1,4-DB eq / kg
Soil	(unspecified)	Carbaryl	0,155	kg 1,4-DB eq / kg
Soil	agricultural	Carbaryl	21	kg 1,4-DB eq / kg
Air	(unspecified)	Carbendazim	19,2	kg 1,4-DB eq / kg
Water	(unspecified)	Carbendazim	2,51	kg 1,4-DB eq / kg
Water	ocean	Carbendazim	0,00201	kg 1,4-DB eq / kg
Soil	(unspecified)	Carbendazim	0,432	kg 1,4-DB eq / kg
Soil	agricultural	Carbendazim	141	kg 1,4-DB eq / kg
Air	(unspecified)	Carbofuran	198	kg 1,4-DB eq / kg
Water	(unspecified)	Carbofuran	56,4	kg 1,4-DB eq / kg
Water	ocean	Carbofuran	0,209	kg 1,4-DB eq / kg
Soil	(unspecified)	Carbofuran	8,03	kg 1,4-DB eq / kg
Soil	agricultural	Carbofuran	1420	kg 1,4-DB eq / kg
Air	(unspecified)	Carbon disulfide	2,41	kg 1,4-DB eq / kg
Water	(unspecified)	Carbon disulfide	2,43	kg 1,4-DB eq / kg
Water	ocean	Carbon disulfide	0,482	kg 1,4-DB eq / kg
Soil	(unspecified)	Carbon disulfide	2,24	kg 1,4-DB eq / kg
Soil	agricultural	Carbon disulfide	3,61	kg 1,4-DB eq / kg
Air	(unspecified)	Chlordane , pur	6740	kg 1,4-DB eq / kg
Water	(unspecified)	Chlordane , pur	741	kg 1,4-DB eq / kg
Water	ocean	Chlordane , pur	1160	kg 1,4-DB eq / kg
Soil	(unspecified)	Chlordane , pur	27,1	kg 1,4-DB eq / kg
Soil	agricultural	Chlordane , pur	2780	kg 1,4-DB eq / kg
Air	(unspecified)	Chlorfenvinphos	271	kg 1,4-DB eq / kg
Water	(unspecified)	Chlorfenvinphos	815	kg 1,4-DB eq / kg
Water	ocean	Chlorfenvinphos	3,85	kg 1,4-DB eq / kg
Soil	(unspecified)	Chlorfenvinphos	44,4	kg 1,4-DB eq / kg
Soil	agricultural	Chlorfenvinphos	1220	kg 1,4-DB eq / kg
Air	(unspecified)	Chloridazon	0,013	kg 1,4-DB eq / kg
Water	(unspecified)	Chloridazon	0,143	kg 1,4-DB eq / kg
Water	ocean	Chloridazon	0,00213	kg 1,4-DB eq / kg
Soil	(unspecified)	Chloridazon	0,0205	kg 1,4-DB eq / kg
Soil	agricultural	Chloridazon	2,18	kg 1,4-DB eq / kg
Air	(unspecified)	Chloroform	12,7	kg 1,4-DB eq / kg
Water	(unspecified)	Chloroform	12,5	kg 1,4-DB eq / kg
Water	ocean	Chloroform	6,02	kg 1,4-DB eq / kg
Soil	(unspecified)	Chloroform	10,1	kg 1,4-DB eq / kg
Soil	agricultural	Chloroform	14,1	kg 1,4-DB eq / kg
Air	(unspecified)	Chlorothalonil	8,39	kg 1,4-DB eq / kg
Water	(unspecified)	Chlorothalonil	6,69	kg 1,4-DB eq / kg
Water	ocean	Chlorothalonil	0,455	kg 1,4-DB eq / kg
Soil	(unspecified)	Chlorothalonil	0,999	kg 1,4-DB eq / kg
Soil	agricultural	Chlorothalonil	0,94	kg 1,4-DB eq / kg

Air	(unspecified)	Chlorpropham	0,335	kg 1,4-DB eq / kg
Water	(unspecified)	Chlorpropham	1,02	kg 1,4-DB eq / kg
Water	ocean	Chlorpropham	0,00432	kg 1,4-DB eq / kg
Soil	(unspecified)	Chlorpropham	0,0815	kg 1,4-DB eq / kg
Soil	agricultural	Chlorpropham	2,12	kg 1,4-DB eq / kg
Air	(unspecified)	Chlorpyrifos	21,2	kg 1,4-DB eq / kg
Water	(unspecified)	Chlorpyrifos	44,3	kg 1,4-DB eq / kg
Water	ocean	Chlorpyrifos	0,038	kg 1,4-DB eq / kg
Soil	(unspecified)	Chlorpyrifos	0,139	kg 1,4-DB eq / kg
Soil	agricultural	Chlorpyrifos	14,5	kg 1,4-DB eq / kg
Air	(unspecified)	Chromium III	647	kg 1,4-DB eq / kg
Water	(unspecified)	Chromium III	2,05	kg 1,4-DB eq / kg
Water	ocean	Chromium III	10	kg 1,4-DB eq / kg
Soil	(unspecified)	Chromium III	300	kg 1,4-DB eq / kg
Soil	agricultural	Chromium III	5130	kg 1,4-DB eq / kg
Air	(unspecified)	Chromium VI	3430000	kg 1,4-DB eq / kg
Water	(unspecified)	Chromium VI	3,42	kg 1,4-DB eq / kg
Water	ocean	Chromium VI	16,7	kg 1,4-DB eq / kg
Soil	(unspecified)	Chromium VI	500	kg 1,4-DB eq / kg
Soil	agricultural	Chromium VI	8550	kg 1,4-DB eq / kg
Air	(unspecified)	Cobalt	17500	kg 1,4-DB eq / kg
Water	(unspecified)	Cobalt	96,7	kg 1,4-DB eq / kg
Water	ocean	Cobalt	60,5	kg 1,4-DB eq / kg
Soil	(unspecified)	Cobalt	59,1	kg 1,4-DB eq / kg
Soil	agricultural	Cobalt	2390	kg 1,4-DB eq / kg
Water	(unspecified)	Copper	1,34	kg 1,4-DB eq / kg
Water	ocean	Copper	5,91	kg 1,4-DB eq / kg
Soil	(unspecified)	Copper II	1,25	kg 1,4-DB eq / kg
Soil	agricultural	Copper II	93,9	kg 1,4-DB eq / kg
Air	(unspecified)	Copper, ion	4300	kg 1,4-DB eq / kg
Air	(unspecified)	Coumafos	777	kg 1,4-DB eq / kg
Water	(unspecified)	Coumafos	10400	kg 1,4-DB eq / kg
Water	ocean	Coumafos	223	kg 1,4-DB eq / kg
Soil	(unspecified)	Coumafos	1610	kg 1,4-DB eq / kg
Soil	agricultural	Coumafos	11000	kg 1,4-DB eq / kg
Air	(unspecified)	Cyanazine	3,5	kg 1,4-DB eq / kg
Water	(unspecified)	Cyanazine	5,95	kg 1,4-DB eq / kg
Water	ocean	Cyanazine	0,00963	kg 1,4-DB eq / kg
Soil	(unspecified)	Cyanazine	0,349	kg 1,4-DB eq / kg
Soil	agricultural	Cyanazine	24,5	kg 1,4-DB eq / kg
Air	(unspecified)	Cypermethrin	166	kg 1,4-DB eq / kg
Water	(unspecified)	Cypermethrin	5,55	kg 1,4-DB eq / kg
Water	ocean	Cypermethrin	0,0258	kg 1,4-DB eq / kg
Soil	(unspecified)	Cypermethrin	1,85	kg 1,4-DB eq / kg
Soil	agricultural	Cypermethrin	5200	kg 1,4-DB eq / kg
Air	(unspecified)	Cyromazine	38,2	kg 1,4-DB eq / kg
Water	(unspecified)	Cyromazine	5,38	kg 1,4-DB eq / kg
Water	ocean	Cyromazine	0,00257	kg 1,4-DB eq / kg
Soil	(unspecified)	Cyromazine	1,32	kg 1,4-DB eq / kg
Soil	agricultural	Cyromazine	279	kg 1,4-DB eq / kg
Air	(unspecified)	DDT	112	kg 1,4-DB eq / kg
Water	(unspecified)	DDT	36,7	kg 1,4-DB eq / kg
Water	ocean	DDT	33,6	kg 1,4-DB eq / kg
Soil	(unspecified)	DDT	1,78	kg 1,4-DB eq / kg
Soil	agricultural	DDT	267	kg 1,4-DB eq / kg
Air	(unspecified)	Deltamethrin	1,62	kg 1,4-DB eq / kg
Water	(unspecified)	Deltamethrin	2,85	kg 1,4-DB eq / kg
Water	ocean	Deltamethrin	0,0329	kg 1,4-DB eq / kg
Soil	(unspecified)	Deltamethrin	0,0301	kg 1,4-DB eq / kg
Soil	agricultural	Deltamethrin	0,16	kg 1,4-DB eq / kg
Air	(unspecified)	Demeton	71,4	kg 1,4-DB eq / kg
Water	(unspecified)	Demeton	721	kg 1,4-DB eq / kg
Water	ocean	Demeton	0,295	kg 1,4-DB eq / kg
Soil	(unspecified)	Demeton	88,8	kg 1,4-DB eq / kg
Soil	agricultural	Demeton	5720	kg 1,4-DB eq / kg
Air	(unspecified)	Desmetryn	94,5	kg 1,4-DB eq / kg
Water	(unspecified)	Desmetryn	49,9	kg 1,4-DB eq / kg
Water	ocean	Desmetryn	0,116	kg 1,4-DB eq / kg
Soil	(unspecified)	Desmetryn	2,91	kg 1,4-DB eq / kg
Soil	agricultural	Desmetryn	648	kg 1,4-DB eq / kg
Air	(unspecified)	Diazinon	59,5	kg 1,4-DB eq / kg
Water	(unspecified)	Diazinon	65,7	kg 1,4-DB eq / kg
Water	ocean	Diazinon	0,273	kg 1,4-DB eq / kg
Soil	(unspecified)	Diazinon	3,19	kg 1,4-DB eq / kg
Soil	agricultural	Diazinon	117	kg 1,4-DB eq / kg
Air	(unspecified)	Dichlorprop	1,12	kg 1,4-DB eq / kg
Water	(unspecified)	Dichlorprop	24	kg 1,4-DB eq / kg
Water	ocean	Dichlorprop	0,0968	kg 1,4-DB eq / kg
Soil	(unspecified)	Dichlorprop	0,26	kg 1,4-DB eq / kg
Soil	agricultural	Dichlorprop	4,52	kg 1,4-DB eq / kg
Air	(unspecified)	Dichlorvos	104	kg 1,4-DB eq / kg
Water	(unspecified)	Dichlorvos	0,343	kg 1,4-DB eq / kg
Water	ocean	Dichlorvos	0,00231	kg 1,4-DB eq / kg
Soil	(unspecified)	Dichlorvos	0,0358	kg 1,4-DB eq / kg
Soil	agricultural	Dichlorvos	0,968	kg 1,4-DB eq / kg
Air	(unspecified)	Dieldrin	12900	kg 1,4-DB eq / kg

Water	(unspecified)	Dieldrin	44900	kg 1,4-DB eq / kg
Water	ocean	Dieldrin	5490	kg 1,4-DB eq / kg
Soil	(unspecified)	Dieldrin	1470	kg 1,4-DB eq / kg
Soil	agricultural	Dieldrin	7560	kg 1,4-DB eq / kg
Air	(unspecified)	Dimethoate	43,5	kg 1,4-DB eq / kg
Water	(unspecified)	Dimethoate	18	kg 1,4-DB eq / kg
Water	ocean	Dimethoate	0,00329	kg 1,4-DB eq / kg
Soil	(unspecified)	Dimethoate	2,99	kg 1,4-DB eq / kg
Soil	agricultural	Dimethoate	318	kg 1,4-DB eq / kg
Air	(unspecified)	Dinoseb	3590	kg 1,4-DB eq / kg
Water	(unspecified)	Dinoseb	157	kg 1,4-DB eq / kg
Water	ocean	Dinoseb	0,632	kg 1,4-DB eq / kg
Soil	(unspecified)	Dinoseb	96,7	kg 1,4-DB eq / kg
Soil	agricultural	Dinoseb	562	kg 1,4-DB eq / kg
Air	(unspecified)	Dinoterb	169	kg 1,4-DB eq / kg
Water	(unspecified)	Dinoterb	2,47	kg 1,4-DB eq / kg
Water	ocean	Dinoterb	0,00293	kg 1,4-DB eq / kg
Soil	(unspecified)	Dinoterb	0,121	kg 1,4-DB eq / kg
Soil	agricultural	Dinoterb	0,356	kg 1,4-DB eq / kg
Air	(unspecified)	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	1930000000	kg 1,4-DB eq / kg
Water	(unspecified)	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	858000000	kg 1,4-DB eq / kg
Water	ocean	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	422000000	kg 1,4-DB eq / kg
Soil	(unspecified)	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	10100000	kg 1,4-DB eq / kg
Soil	agricultural	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	1300000000	kg 1,4-DB eq / kg
Air	(unspecified)	Dioxins (unspec.)	1930000000	kg 1,4-DB eq / kg
Air	(unspecified)	Disulfoton	287	kg 1,4-DB eq / kg
Water	(unspecified)	Disulfoton	345	kg 1,4-DB eq / kg
Water	ocean	Disulfoton	1,54	kg 1,4-DB eq / kg
Soil	(unspecified)	Disulfoton	2,04	kg 1,4-DB eq / kg
Soil	agricultural	Disulfoton	168	kg 1,4-DB eq / kg
Air	(unspecified)	Diuron	214	kg 1,4-DB eq / kg
Water	(unspecified)	Diuron	53,1	kg 1,4-DB eq / kg
Water	ocean	Diuron	0,185	kg 1,4-DB eq / kg
Soil	(unspecified)	Diuron	7,24	kg 1,4-DB eq / kg
Soil	agricultural	Diuron	1270	kg 1,4-DB eq / kg
Air	(unspecified)	DNOC	160	kg 1,4-DB eq / kg
Water	(unspecified)	DNOC	58,7	kg 1,4-DB eq / kg
Water	ocean	DNOC	0,00149	kg 1,4-DB eq / kg
Soil	(unspecified)	DNOC	2,77	kg 1,4-DB eq / kg
Soil	agricultural	DNOC	276	kg 1,4-DB eq / kg
Air	(unspecified)	Endosulfan	6,68	kg 1,4-DB eq / kg
Water	(unspecified)	Endosulfan	17,3	kg 1,4-DB eq / kg
Water	ocean	Endosulfan	0,0423	kg 1,4-DB eq / kg
Soil	(unspecified)	Endosulfan	0,0162	kg 1,4-DB eq / kg
Soil	agricultural	Endosulfan	0,263	kg 1,4-DB eq / kg
Air	(unspecified)	Endrin	1180	kg 1,4-DB eq / kg
Water	(unspecified)	Endrin	6040	kg 1,4-DB eq / kg
Water	ocean	Endrin	1640	kg 1,4-DB eq / kg
Soil	(unspecified)	Endrin	754	kg 1,4-DB eq / kg
Soil	agricultural	Endrin	8440	kg 1,4-DB eq / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	16,4	kg 1,4-DB eq / kg
Water	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	16,2	kg 1,4-DB eq / kg
Water	ocean	Ethane, 1,1,1-trichloro-, HCFC-140	9,65	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	15,7	kg 1,4-DB eq / kg
Soil	agricultural	Ethane, 1,1,1-trichloro-, HCFC-140	16	kg 1,4-DB eq / kg
Air	(unspecified)	Ethane, 1,2-dichloro-	6,81	kg 1,4-DB eq / kg
Water	(unspecified)	Ethane, 1,2-dichloro-	27,9	kg 1,4-DB eq / kg
Water	ocean	Ethane, 1,2-dichloro-	5,45	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethane, 1,2-dichloro-	5,67	kg 1,4-DB eq / kg
Soil	agricultural	Ethane, 1,2-dichloro-	1290	kg 1,4-DB eq / kg
Air	(unspecified)	Ethene	0,637	kg 1,4-DB eq / kg
Water	(unspecified)	Ethene	0,654	kg 1,4-DB eq / kg
Water	ocean	Ethene	0,0471	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethene	0,617	kg 1,4-DB eq / kg
Soil	agricultural	Ethene	0,78	kg 1,4-DB eq / kg
Air	(unspecified)	Ethene, chloro-	84,3	kg 1,4-DB eq / kg
Water	(unspecified)	Ethene, chloro-	145	kg 1,4-DB eq / kg
Water	ocean	Ethene, chloro-	42,6	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethene, chloro-	82,6	kg 1,4-DB eq / kg
Soil	agricultural	Ethene, chloro-	517	kg 1,4-DB eq / kg
Air	(unspecified)	Ethene, tetrachloro-	5,53	kg 1,4-DB eq / kg
Water	(unspecified)	Ethene, tetrachloro-	5,72	kg 1,4-DB eq / kg
Water	ocean	Ethene, tetrachloro-	2,75	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethene, tetrachloro-	5,16	kg 1,4-DB eq / kg
Soil	agricultural	Ethene, tetrachloro-	6,42	kg 1,4-DB eq / kg
Air	(unspecified)	Ethene, trichloro-	34,4	kg 1,4-DB eq / kg
Water	(unspecified)	Ethene, trichloro-	33,5	kg 1,4-DB eq / kg
Water	ocean	Ethene, trichloro-	14,1	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethene, trichloro-	31,6	kg 1,4-DB eq / kg
Air	(unspecified)	Ethoprop	1090	kg 1,4-DB eq / kg
Water	(unspecified)	Ethoprop	1770	kg 1,4-DB eq / kg
Water	ocean	Ethoprop	13,4	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethoprop	377	kg 1,4-DB eq / kg
Soil	agricultural	Ethoprop	5680	kg 1,4-DB eq / kg
Air	(unspecified)	Ethylene oxide	14100	kg 1,4-DB eq / kg
Water	(unspecified)	Ethylene oxide	11400	kg 1,4-DB eq / kg

Water	ocean	Ethylene oxide	541	kg 1,4-DB eq / kg
Soil	(unspecified)	Ethylene oxide	4580	kg 1,4-DB eq / kg
Soil	agricultural	Ethylene oxide	107000	kg 1,4-DB eq / kg
Air	(unspecified)	Fenitrothion	5,94	kg 1,4-DB eq / kg
Water	(unspecified)	Fenitrothion	22,2	kg 1,4-DB eq / kg
Water	ocean	Fenitrothion	0,0896	kg 1,4-DB eq / kg
Soil	(unspecified)	Fenitrothion	0,324	kg 1,4-DB eq / kg
Soil	agricultural	Fenitrothion	12	kg 1,4-DB eq / kg
Air	(unspecified)	Fenthion	62,8	kg 1,4-DB eq / kg
Water	(unspecified)	Fenthion	92,9	kg 1,4-DB eq / kg
Water	ocean	Fenthion	0,465	kg 1,4-DB eq / kg
Soil	(unspecified)	Fenthion	1,53	kg 1,4-DB eq / kg
Soil	agricultural	Fenthion	30,5	kg 1,4-DB eq / kg
Air	(unspecified)	Fentin acetate	2230	kg 1,4-DB eq / kg
Water	(unspecified)	Fentin acetate	875	kg 1,4-DB eq / kg
Water	ocean	Fentin acetate	4,14	kg 1,4-DB eq / kg
Soil	(unspecified)	Fentin acetate	9,2	kg 1,4-DB eq / kg
Soil	agricultural	Fentin acetate	71,7	kg 1,4-DB eq / kg
Air	(unspecified)	Fentin chloride	837	kg 1,4-DB eq / kg
Water	(unspecified)	Fentin chloride	861	kg 1,4-DB eq / kg
Water	ocean	Fentin chloride	12,1	kg 1,4-DB eq / kg
Soil	(unspecified)	Fentin chloride	12,9	kg 1,4-DB eq / kg
Soil	agricultural	Fentin chloride	131	kg 1,4-DB eq / kg
Air	(unspecified)	Fentin hydroxide	849	kg 1,4-DB eq / kg
Water	(unspecified)	Fentin hydroxide	873	kg 1,4-DB eq / kg
Water	ocean	Fentin hydroxide	4,1	kg 1,4-DB eq / kg
Soil	(unspecified)	Fentin hydroxide	8,5	kg 1,4-DB eq / kg
Soil	agricultural	Fentin hydroxide	87,9	kg 1,4-DB eq / kg
Air	(unspecified)	Folpet	1,97	kg 1,4-DB eq / kg
Water	(unspecified)	Folpet	8,63	kg 1,4-DB eq / kg
Water	ocean	Folpet	0,314	kg 1,4-DB eq / kg
Soil	(unspecified)	Folpet	1,5	kg 1,4-DB eq / kg
Soil	agricultural	Folpet	12,8	kg 1,4-DB eq / kg
Air	(unspecified)	Formaldehyde	0,831	kg 1,4-DB eq / kg
Water	(unspecified)	Formaldehyde	0,0371	kg 1,4-DB eq / kg
Water	ocean	Formaldehyde	0,0000282	kg 1,4-DB eq / kg
Soil	(unspecified)	Formaldehyde	0,019	kg 1,4-DB eq / kg
Soil	agricultural	Formaldehyde	2,27	kg 1,4-DB eq / kg
Air	(unspecified)	Glyphosate	0,0031	kg 1,4-DB eq / kg
Water	(unspecified)	Glyphosate	0,0662	kg 1,4-DB eq / kg
Water	ocean	Glyphosate	0,0000151	kg 1,4-DB eq / kg
Soil	(unspecified)	Glyphosate	0,000649	kg 1,4-DB eq / kg
Soil	agricultural	Glyphosate	0,0149	kg 1,4-DB eq / kg
Air	(unspecified)	Heptachlor	40	kg 1,4-DB eq / kg
Water	(unspecified)	Heptachlor	3440	kg 1,4-DB eq / kg
Water	ocean	Heptachlor	42,8	kg 1,4-DB eq / kg
Soil	(unspecified)	Heptachlor	4,44	kg 1,4-DB eq / kg
Soil	agricultural	Heptachlor	669	kg 1,4-DB eq / kg
Air	(unspecified)	Heptenophos	23	kg 1,4-DB eq / kg
Water	(unspecified)	Heptenophos	1,28	kg 1,4-DB eq / kg
Water	ocean	Heptenophos	0,00229	kg 1,4-DB eq / kg
Soil	(unspecified)	Heptenophos	0,0203	kg 1,4-DB eq / kg
Soil	agricultural	Heptenophos	3,38	kg 1,4-DB eq / kg
Air	(unspecified)	Hydrogen chloride	0,5	kg 1,4-DB eq / kg
Air	(unspecified)	Hydrogen fluoride	2850	kg 1,4-DB eq / kg
Water	(unspecified)	Hydrogen fluoride	3640	kg 1,4-DB eq / kg
Soil	(unspecified)	Hydrogen fluoride	1820	kg 1,4-DB eq / kg
Soil	agricultural	Hydrogen fluoride	1850	kg 1,4-DB eq / kg
Air	(unspecified)	Hydrogen sulfide	0,22	kg 1,4-DB eq / kg
Air	(unspecified)	Iprodione	0,276	kg 1,4-DB eq / kg
Water	(unspecified)	Iprodione	0,184	kg 1,4-DB eq / kg
Water	ocean	Iprodione	0,000119	kg 1,4-DB eq / kg
Soil	(unspecified)	Iprodione	0,00318	kg 1,4-DB eq / kg
Soil	agricultural	Iprodione	1,84	kg 1,4-DB eq / kg
Air	(unspecified)	Isoproturon	131	kg 1,4-DB eq / kg
Water	(unspecified)	Isoproturon	13,2	kg 1,4-DB eq / kg
Water	ocean	Isoproturon	0,029	kg 1,4-DB eq / kg
Soil	(unspecified)	Isoproturon	2,8	kg 1,4-DB eq / kg
Soil	agricultural	Isoproturon	961	kg 1,4-DB eq / kg
Water	(unspecified)	Lead	12,3	kg 1,4-DB eq / kg
Water	ocean	Lead	78,8	kg 1,4-DB eq / kg
Air	(unspecified)	Lead, ion	467	kg 1,4-DB eq / kg
Soil	(unspecified)	Lead, ion	293	kg 1,4-DB eq / kg
Soil	agricultural	Lead, ion	3280	kg 1,4-DB eq / kg
Air	(unspecified)	Lindane	610	kg 1,4-DB eq / kg
Water	(unspecified)	Lindane	826	kg 1,4-DB eq / kg
Water	ocean	Lindane	6,15	kg 1,4-DB eq / kg
Soil	(unspecified)	Lindane	52	kg 1,4-DB eq / kg
Soil	agricultural	Lindane	489	kg 1,4-DB eq / kg
Air	(unspecified)	Linuron	13,8	kg 1,4-DB eq / kg
Water	(unspecified)	Linuron	115	kg 1,4-DB eq / kg
Water	ocean	Linuron	0,654	kg 1,4-DB eq / kg
Soil	(unspecified)	Linuron	9,43	kg 1,4-DB eq / kg
Soil	agricultural	Linuron	169	kg 1,4-DB eq / kg
Air	(unspecified)	m-Xylene	0,0271	kg 1,4-DB eq / kg
Water	(unspecified)	m-Xylene	0,337	kg 1,4-DB eq / kg

Water	ocean	m-Xylene	0,0103	kg 1,4-DB eq / kg
Soil	(unspecified)	m-Xylene	0,0189	kg 1,4-DB eq / kg
Soil	agricultural	m-Xylene	3,8	kg 1,4-DB eq / kg
Air	(unspecified)	Malathion	0,0353	kg 1,4-DB eq / kg
Water	(unspecified)	Malathion	0,245	kg 1,4-DB eq / kg
Water	ocean	Malathion	0,000841	kg 1,4-DB eq / kg
Soil	(unspecified)	Malathion	0,000948	kg 1,4-DB eq / kg
Soil	agricultural	Malathion	0,0257	kg 1,4-DB eq / kg
Air	(unspecified)	Mecoprop	119	kg 1,4-DB eq / kg
Water	(unspecified)	Mecoprop	205	kg 1,4-DB eq / kg
Water	ocean	Mecoprop	0,843	kg 1,4-DB eq / kg
Soil	(unspecified)	Mecoprop	42,4	kg 1,4-DB eq / kg
Soil	agricultural	Mecoprop	744	kg 1,4-DB eq / kg
Water	(unspecified)	Mercury	1430	kg 1,4-DB eq / kg
Water	ocean	Mercury	8200	kg 1,4-DB eq / kg
Air	(unspecified)	Mercury II	6010	kg 1,4-DB eq / kg
Soil	(unspecified)	Mercury II	1080	kg 1,4-DB eq / kg
Soil	agricultural	Mercury II	5920	kg 1,4-DB eq / kg
Air	(unspecified)	Metamitron	0,879	kg 1,4-DB eq / kg
Water	(unspecified)	Metamitron	0,161	kg 1,4-DB eq / kg
Water	ocean	Metamitron	0,0000318	kg 1,4-DB eq / kg
Soil	(unspecified)	Metamitron	0,0117	kg 1,4-DB eq / kg
Soil	agricultural	Metamitron	6,46	kg 1,4-DB eq / kg
Air	(unspecified)	Metazachlor	6,82	kg 1,4-DB eq / kg
Water	(unspecified)	Metazachlor	1,69	kg 1,4-DB eq / kg
Water	ocean	Metazachlor	0,00242	kg 1,4-DB eq / kg
Soil	(unspecified)	Metazachlor	0,155	kg 1,4-DB eq / kg
Soil	agricultural	Metazachlor	49,1	kg 1,4-DB eq / kg
Air	(unspecified)	Methabenzthiazuron	7,13	kg 1,4-DB eq / kg
Water	(unspecified)	Methabenzthiazuron	2,62	kg 1,4-DB eq / kg
Water	ocean	Methabenzthiazuron	0,00824	kg 1,4-DB eq / kg
Soil	(unspecified)	Methabenzthiazuron	0,359	kg 1,4-DB eq / kg
Soil	agricultural	Methabenzthiazuron	50,8	kg 1,4-DB eq / kg
Air	(unspecified)	Methane, bromo-, Halon 1001	351	kg 1,4-DB eq / kg
Water	(unspecified)	Methane, bromo-, Halon 1001	298	kg 1,4-DB eq / kg
Water	ocean	Methane, bromo-, Halon 1001	24,9	kg 1,4-DB eq / kg
Soil	(unspecified)	Methane, bromo-, Halon 1001	263	kg 1,4-DB eq / kg
Soil	agricultural	Methane, bromo-, Halon 1001	262	kg 1,4-DB eq / kg
Air	(unspecified)	Methane, dichloro-, HCC-30	1,98	kg 1,4-DB eq / kg
Water	(unspecified)	Methane, dichloro-, HCC-30	1,84	kg 1,4-DB eq / kg
Water	ocean	Methane, dichloro-, HCC-30	0,298	kg 1,4-DB eq / kg
Soil	(unspecified)	Methane, dichloro-, HCC-30	1,3	kg 1,4-DB eq / kg
Soil	agricultural	Methane, dichloro-, HCC-30	2,45	kg 1,4-DB eq / kg
Air	(unspecified)	Methane, tetrachloro-, CFC-10	220	kg 1,4-DB eq / kg
Water	(unspecified)	Methane, tetrachloro-, CFC-10	220	kg 1,4-DB eq / kg
Water	ocean	Methane, tetrachloro-, CFC-10	168	kg 1,4-DB eq / kg
Soil	(unspecified)	Methane, tetrachloro-, CFC-10	219	kg 1,4-DB eq / kg
Soil	agricultural	Methane, tetrachloro-, CFC-10	222	kg 1,4-DB eq / kg
Air	(unspecified)	Methomyl	6,16	kg 1,4-DB eq / kg
Water	(unspecified)	Methomyl	3,27	kg 1,4-DB eq / kg
Water	ocean	Methomyl	0,0014	kg 1,4-DB eq / kg
Soil	(unspecified)	Methomyl	0,693	kg 1,4-DB eq / kg
Soil	agricultural	Methomyl	43,3	kg 1,4-DB eq / kg
Air	(unspecified)	Methylmercury	57600	kg 1,4-DB eq / kg
Water	(unspecified)	Methylmercury	15400	kg 1,4-DB eq / kg
Water	ocean	Methylmercury	88000	kg 1,4-DB eq / kg
Soil	(unspecified)	Methylmercury	10500	kg 1,4-DB eq / kg
Soil	agricultural	Methylmercury	20300	kg 1,4-DB eq / kg
Air	(unspecified)	Metobromuron	55,4	kg 1,4-DB eq / kg
Water	(unspecified)	Metobromuron	7,97	kg 1,4-DB eq / kg
Water	ocean	Metobromuron	0,0763	kg 1,4-DB eq / kg
Soil	(unspecified)	Metobromuron	1,93	kg 1,4-DB eq / kg
Soil	agricultural	Metobromuron	413	kg 1,4-DB eq / kg
Air	(unspecified)	Metolachlor	2,58	kg 1,4-DB eq / kg
Water	(unspecified)	Metolachlor	0,554	kg 1,4-DB eq / kg
Water	ocean	Metolachlor	0,000852	kg 1,4-DB eq / kg
Soil	(unspecified)	Metolachlor	0,11	kg 1,4-DB eq / kg
Soil	agricultural	Metolachlor	11,4	kg 1,4-DB eq / kg
Air	(unspecified)	Mevinfos	1,04	kg 1,4-DB eq / kg
Water	(unspecified)	Mevinfos	10,6	kg 1,4-DB eq / kg
Water	ocean	Mevinfos	0,00185	kg 1,4-DB eq / kg
Soil	(unspecified)	Mevinfos	0,0554	kg 1,4-DB eq / kg
Soil	agricultural	Mevinfos	5,72	kg 1,4-DB eq / kg
Air	(unspecified)	Molybdenum	5430	kg 1,4-DB eq / kg
Water	(unspecified)	Molybdenum	5510	kg 1,4-DB eq / kg
Water	ocean	Molybdenum	6790	kg 1,4-DB eq / kg
Soil	(unspecified)	Molybdenum	3060	kg 1,4-DB eq / kg
Soil	agricultural	Molybdenum	6170	kg 1,4-DB eq / kg
Air	(unspecified)	Naphthalene	8,11	kg 1,4-DB eq / kg
Water	(unspecified)	Naphthalene	5,55	kg 1,4-DB eq / kg
Water	ocean	Naphthalene	0,194	kg 1,4-DB eq / kg
Soil	(unspecified)	Naphthalene	1,63	kg 1,4-DB eq / kg
Soil	agricultural	Naphthalene	4,81	kg 1,4-DB eq / kg
Water	(unspecified)	Nickel	331	kg 1,4-DB eq / kg
Water	ocean	Nickel	747	kg 1,4-DB eq / kg
Air	(unspecified)	Nickel II	35000	kg 1,4-DB eq / kg

Soil	(unspecified)	Nickel II	198	kg 1,4-DB eq / kg
Soil	agricultural	Nickel II	2680	kg 1,4-DB eq / kg
Air	(unspecified)	Nitrogen dioxide	1,2	kg 1,4-DB eq / kg
Air	(unspecified)	Nitrogen oxides	1,2	kg 1,4-DB eq / kg
Air	(unspecified)	o-Xylene	0,125	kg 1,4-DB eq / kg
Water	(unspecified)	o-Xylene	0,425	kg 1,4-DB eq / kg
Water	ocean	o-Xylene	0,0258	kg 1,4-DB eq / kg
Soil	(unspecified)	o-Xylene	0,0765	kg 1,4-DB eq / kg
Soil	agricultural	o-Xylene	5,02	kg 1,4-DB eq / kg
Air	(unspecified)	Oxamyl	1,4	kg 1,4-DB eq / kg
Water	(unspecified)	Oxamyl	0,355	kg 1,4-DB eq / kg
Water	ocean	Oxamyl	0,0000143	kg 1,4-DB eq / kg
Soil	(unspecified)	Oxamyl	0,0676	kg 1,4-DB eq / kg
Soil	agricultural	Oxamyl	10,1	kg 1,4-DB eq / kg
Air	(unspecified)	Oxydemeton methyl	122	kg 1,4-DB eq / kg
Water	(unspecified)	Oxydemeton methyl	74,2	kg 1,4-DB eq / kg
Water	ocean	Oxydemeton methyl	0,0102	kg 1,4-DB eq / kg
Soil	(unspecified)	Oxydemeton methyl	3,84	kg 1,4-DB eq / kg
Soil	agricultural	Oxydemeton methyl	611	kg 1,4-DB eq / kg
Air	(unspecified)	p-Xylene	0,0432	kg 1,4-DB eq / kg
Water	(unspecified)	p-Xylene	0,351	kg 1,4-DB eq / kg
Water	ocean	p-Xylene	0,013	kg 1,4-DB eq / kg
Soil	(unspecified)	p-Xylene	0,0253	kg 1,4-DB eq / kg
Soil	agricultural	p-Xylene	3,03	kg 1,4-DB eq / kg
Air	(unspecified)	PAH, polycyclic aromatic hydrocarbons, carcinogenic	572000	kg 1,4-DB eq / kg
Water	(unspecified)	PAH, polycyclic aromatic hydrocarbons, carcinogenic	280000	kg 1,4-DB eq / kg
Water	ocean	PAH, polycyclic aromatic hydrocarbons, carcinogenic	28800	kg 1,4-DB eq / kg
Soil	(unspecified)	PAH, polycyclic aromatic hydrocarbons, carcinogenic	2730	kg 1,4-DB eq / kg
Soil	agricultural	PAH, polycyclic aromatic hydrocarbons, carcinogenic	71000	kg 1,4-DB eq / kg
Air	(unspecified)	Parathion	3,34	kg 1,4-DB eq / kg
Water	(unspecified)	Parathion	31	kg 1,4-DB eq / kg
Water	ocean	Parathion	0,185	kg 1,4-DB eq / kg
Soil	(unspecified)	Parathion	0,111	kg 1,4-DB eq / kg
Soil	agricultural	Parathion	2,92	kg 1,4-DB eq / kg
Air	(unspecified)	Parathion, methyl	52,7	kg 1,4-DB eq / kg
Water	(unspecified)	Parathion, methyl	103	kg 1,4-DB eq / kg
Water	ocean	Parathion, methyl	0,538	kg 1,4-DB eq / kg
Soil	(unspecified)	Parathion, methyl	1,74	kg 1,4-DB eq / kg
Soil	agricultural	Parathion, methyl	23,6	kg 1,4-DB eq / kg
Air	(unspecified)	Particulates, < 10 um	0,82	kg 1,4-DB eq / kg
Air	(unspecified)	Particulates, < 10 um (mobile)	0,82	kg 1,4-DB eq / kg
Air	(unspecified)	Particulates, < 10 um (stationary)	0,82	kg 1,4-DB eq / kg
Air	(unspecified)	Particulates, < 2.5 um	0,82	kg 1,4-DB eq / kg
Air	(unspecified)	Particulates, > 2.5 um, and < 10um	0,82	kg 1,4-DB eq / kg
Air	(unspecified)	Permethrin	0,85	kg 1,4-DB eq / kg
Water	(unspecified)	Permethrin	22,5	kg 1,4-DB eq / kg
Water	ocean	Permethrin	0,255	kg 1,4-DB eq / kg
Soil	(unspecified)	Permethrin	0,0211	kg 1,4-DB eq / kg
Soil	agricultural	Permethrin	11,3	kg 1,4-DB eq / kg
Air	(unspecified)	Phenol	0,518	kg 1,4-DB eq / kg
Water	(unspecified)	Phenol	0,0492	kg 1,4-DB eq / kg
Water	ocean	Phenol	0,0000796	kg 1,4-DB eq / kg
Soil	(unspecified)	Phenol	0,00604	kg 1,4-DB eq / kg
Soil	agricultural	Phenol	1,86	kg 1,4-DB eq / kg
Air	(unspecified)	Phenol, 2-chloro-	22,1	kg 1,4-DB eq / kg
Water	(unspecified)	Phenol, 2-chloro-	69,6	kg 1,4-DB eq / kg
Water	ocean	Phenol, 2-chloro-	0,355	kg 1,4-DB eq / kg
Soil	(unspecified)	Phenol, 2-chloro-	1,37	kg 1,4-DB eq / kg
Soil	agricultural	Phenol, 2-chloro-	8,33	kg 1,4-DB eq / kg
Air	(unspecified)	Phenol, 2,3,4,6-tetrachloro-	288	kg 1,4-DB eq / kg
Water	(unspecified)	Phenol, 2,3,4,6-tetrachloro-	35,2	kg 1,4-DB eq / kg
Water	ocean	Phenol, 2,3,4,6-tetrachloro-	0,263	kg 1,4-DB eq / kg
Soil	(unspecified)	Phenol, 2,3,4,6-tetrachloro-	1,6	kg 1,4-DB eq / kg
Soil	agricultural	Phenol, 2,3,4,6-tetrachloro-	30,6	kg 1,4-DB eq / kg
Air	(unspecified)	Phenol, 2,4-dichloro-	95,3	kg 1,4-DB eq / kg
Water	(unspecified)	Phenol, 2,4-dichloro-	16,1	kg 1,4-DB eq / kg
Water	ocean	Phenol, 2,4-dichloro-	0,065	kg 1,4-DB eq / kg
Soil	(unspecified)	Phenol, 2,4-dichloro-	1,88	kg 1,4-DB eq / kg
Soil	agricultural	Phenol, 2,4-dichloro-	741	kg 1,4-DB eq / kg
Air	(unspecified)	Phenol, 2,4,5-trichloro-	8,32	kg 1,4-DB eq / kg
Water	(unspecified)	Phenol, 2,4,5-trichloro-	45,2	kg 1,4-DB eq / kg
Water	ocean	Phenol, 2,4,5-trichloro-	0,607	kg 1,4-DB eq / kg
Soil	(unspecified)	Phenol, 2,4,5-trichloro-	2,93	kg 1,4-DB eq / kg
Soil	agricultural	Phenol, 2,4,5-trichloro-	5,28	kg 1,4-DB eq / kg
Air	(unspecified)	Phenol, 2,4,6-trichloro-	13900	kg 1,4-DB eq / kg
Water	(unspecified)	Phenol, 2,4,6-trichloro-	9150	kg 1,4-DB eq / kg
Water	ocean	Phenol, 2,4,6-trichloro-	46,8	kg 1,4-DB eq / kg
Soil	(unspecified)	Phenol, 2,4,6-trichloro-	170	kg 1,4-DB eq / kg
Soil	agricultural	Phenol, 2,4,6-trichloro-	1800	kg 1,4-DB eq / kg
Air	(unspecified)	Phenol, pentachloro-	5,08	kg 1,4-DB eq / kg
Water	(unspecified)	Phenol, pentachloro-	7,24	kg 1,4-DB eq / kg
Water	ocean	Phenol, pentachloro-	0,139	kg 1,4-DB eq / kg
Soil	(unspecified)	Phenol, pentachloro-	0,0392	kg 1,4-DB eq / kg
Soil	agricultural	Phenol, pentachloro-	0,149	kg 1,4-DB eq / kg
Air	(unspecified)	Phoxim	0,968	kg 1,4-DB eq / kg
Water	(unspecified)	Phoxim	11,9	kg 1,4-DB eq / kg

Water	ocean	Phoxim	0,294	kg 1,4-DB eq / kg
Soil	(unspecified)	Phoxim	0,384	kg 1,4-DB eq / kg
Soil	agricultural	Phoxim	25,3	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, butyl-benzyl-	10,2	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, butyl-benzyl-	0,0861	kg 1,4-DB eq / kg
Water	ocean	Phthalate, butyl-benzyl-	0,000852	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, butyl-benzyl-	0,00183	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, butyl-benzyl-	0,31	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, dibutyl-	25,3	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, dibutyl-	0,537	kg 1,4-DB eq / kg
Water	ocean	Phthalate, dibutyl-	0,00301	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, dibutyl-	0,0132	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, dibutyl-	1,31	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, diethyl-	0,316	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, diethyl-	0,136	kg 1,4-DB eq / kg
Water	ocean	Phthalate, diethyl-	0,00057	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, diethyl-	0,00331	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, diethyl-	0,0573	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, dihexyl-	7020	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, dihexyl-	14300	kg 1,4-DB eq / kg
Water	ocean	Phthalate, dihexyl-	369	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, dihexyl-	13,6	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, dihexyl-	1190	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, diisodecyl-	45,6	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, diisodecyl-	18,7	kg 1,4-DB eq / kg
Water	ocean	Phthalate, diisodecyl-	3,16	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, diisodecyl-	0,0384	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, diisodecyl-	112	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, diisooctyl-	307	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, diisooctyl-	17,7	kg 1,4-DB eq / kg
Water	ocean	Phthalate, diisooctyl-	9,68	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, diisooctyl-	0,0517	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, diisooctyl-	32,1	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, dimethyl-	208	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, dimethyl-	7,15	kg 1,4-DB eq / kg
Water	ocean	Phthalate, dimethyl-	0,00839	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, dimethyl-	28,5	kg 1,4-DB eq / kg
Soil	industrial	Phthalate, dimethyl-	0,269	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, dioctyl-	2,61	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, dioctyl-	0,913	kg 1,4-DB eq / kg
Water	ocean	Phthalate, dioctyl-	0,0398	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, dioctyl-	0,00519	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, dioctyl-	1,78	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalate, n-dioctyl-	18,7	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalate, n-dioctyl-	6,34	kg 1,4-DB eq / kg
Water	ocean	Phthalate, n-dioctyl-	1,29	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalate, n-dioctyl-	0,00879	kg 1,4-DB eq / kg
Soil	agricultural	Phthalate, n-dioctyl-	8,56	kg 1,4-DB eq / kg
Air	(unspecified)	Phthalic anhydride	0,412	kg 1,4-DB eq / kg
Water	(unspecified)	Phthalic anhydride	0,000115	kg 1,4-DB eq / kg
Water	ocean	Phthalic anhydride	0,000000101	kg 1,4-DB eq / kg
Soil	(unspecified)	Phthalic anhydride	0,000000658	kg 1,4-DB eq / kg
Soil	agricultural	Phthalic anhydride	0,0101	kg 1,4-DB eq / kg
Air	(unspecified)	Pirimicarb	3,44	kg 1,4-DB eq / kg
Water	(unspecified)	Pirimicarb	1,66	kg 1,4-DB eq / kg
Water	ocean	Pirimicarb	0,00128	kg 1,4-DB eq / kg
Soil	(unspecified)	Pirimicarb	0,289	kg 1,4-DB eq / kg
Soil	agricultural	Pirimicarb	26,1	kg 1,4-DB eq / kg
Air	(unspecified)	Propachlor	12,5	kg 1,4-DB eq / kg
Water	(unspecified)	Propachlor	1,61	kg 1,4-DB eq / kg
Water	ocean	Propachlor	0,0026	kg 1,4-DB eq / kg
Soil	(unspecified)	Propachlor	0,142	kg 1,4-DB eq / kg
Soil	agricultural	Propachlor	15,3	kg 1,4-DB eq / kg
Air	(unspecified)	Propoxur	36,7	kg 1,4-DB eq / kg
Water	(unspecified)	Propoxur	1,26	kg 1,4-DB eq / kg
Water	ocean	Propoxur	0,00039	kg 1,4-DB eq / kg
Soil	(unspecified)	Propoxur	0,266	kg 1,4-DB eq / kg
Soil	agricultural	Propoxur	272	kg 1,4-DB eq / kg
Air	(unspecified)	Propylene oxide	1260	kg 1,4-DB eq / kg
Water	(unspecified)	Propylene oxide	2640	kg 1,4-DB eq / kg
Water	ocean	Propylene oxide	15,8	kg 1,4-DB eq / kg
Soil	(unspecified)	Propylene oxide	587	kg 1,4-DB eq / kg
Soil	agricultural	Propylene oxide	220000	kg 1,4-DB eq / kg
Air	(unspecified)	Pyrazophos	24,5	kg 1,4-DB eq / kg
Water	(unspecified)	Pyrazophos	52,8	kg 1,4-DB eq / kg
Water	ocean	Pyrazophos	0,228	kg 1,4-DB eq / kg
Soil	(unspecified)	Pyrazophos	1,2	kg 1,4-DB eq / kg
Soil	agricultural	Pyrazophos	51,5	kg 1,4-DB eq / kg
Air	(unspecified)	Selenium	47700	kg 1,4-DB eq / kg
Water	(unspecified)	Selenium	56000	kg 1,4-DB eq / kg
Water	ocean	Selenium	62900	kg 1,4-DB eq / kg
Soil	(unspecified)	Selenium	28100	kg 1,4-DB eq / kg
Soil	agricultural	Selenium	28900	kg 1,4-DB eq / kg
Air	(unspecified)	Simazine	33,3	kg 1,4-DB eq / kg
Water	(unspecified)	Simazine	9,74	kg 1,4-DB eq / kg
Water	ocean	Simazine	0,016	kg 1,4-DB eq / kg

Soil	(unspecified)	Simazine	2,19	kg 1,4-DB eq / kg
Soil	agricultural	Simazine	206	kg 1,4-DB eq / kg
Air	(unspecified)	Styrene	0,0474	kg 1,4-DB eq / kg
Water	(unspecified)	Styrene	0,0851	kg 1,4-DB eq / kg
Water	ocean	Styrene	0,0102	kg 1,4-DB eq / kg
Soil	(unspecified)	Styrene	0,0175	kg 1,4-DB eq / kg
Soil	agricultural	Styrene	0,477	kg 1,4-DB eq / kg
Air	(unspecified)	Sulfur dioxide	0,096	kg 1,4-DB eq / kg
Air	(unspecified)	Thallium	432000	kg 1,4-DB eq / kg
Water	(unspecified)	Thallium	225000	kg 1,4-DB eq / kg
Water	ocean	Thallium	294000	kg 1,4-DB eq / kg
Soil	(unspecified)	Thallium	118000	kg 1,4-DB eq / kg
Soil	agricultural	Thallium	2020000	kg 1,4-DB eq / kg
Air	(unspecified)	Thiram	18,9	kg 1,4-DB eq / kg
Water	(unspecified)	Thiram	3,31	kg 1,4-DB eq / kg
Water	ocean	Thiram	0,00066	kg 1,4-DB eq / kg
Soil	(unspecified)	Thiram	0,253	kg 1,4-DB eq / kg
Soil	agricultural	Thiram	7,91	kg 1,4-DB eq / kg
Water	(unspecified)	Tin	0,0173	kg 1,4-DB eq / kg
Water	ocean	Tin	0,105	kg 1,4-DB eq / kg
Air	(unspecified)	Tin, ion	1,73	kg 1,4-DB eq / kg
Soil	(unspecified)	Tin, ion	0,525	kg 1,4-DB eq / kg
Soil	agricultural	Tin, ion	13,1	kg 1,4-DB eq / kg
Air	(unspecified)	Tolclophos-methyl	0,0596	kg 1,4-DB eq / kg
Water	(unspecified)	Tolclophos-methyl	1,05	kg 1,4-DB eq / kg
Water	ocean	Tolclophos-methyl	0,0653	kg 1,4-DB eq / kg
Soil	(unspecified)	Tolclophos-methyl	0,0397	kg 1,4-DB eq / kg
Soil	agricultural	Tolclophos-methyl	10,9	kg 1,4-DB eq / kg
Air	(unspecified)	Toluene	0,327	kg 1,4-DB eq / kg
Water	(unspecified)	Toluene	0,303	kg 1,4-DB eq / kg
Water	ocean	Toluene	0,0385	kg 1,4-DB eq / kg
Soil	(unspecified)	Toluene	0,208	kg 1,4-DB eq / kg
Soil	agricultural	Toluene	0,347	kg 1,4-DB eq / kg
Air	(unspecified)	Triallate	9,69	kg 1,4-DB eq / kg
Water	(unspecified)	Triallate	83,4	kg 1,4-DB eq / kg
Water	ocean	Triallate	1,21	kg 1,4-DB eq / kg
Soil	(unspecified)	Triallate	0,357	kg 1,4-DB eq / kg
Soil	agricultural	Triallate	5,75	kg 1,4-DB eq / kg
Air	(unspecified)	Triazofos	210	kg 1,4-DB eq / kg
Water	(unspecified)	Triazofos	318	kg 1,4-DB eq / kg
Water	ocean	Triazofos	1,56	kg 1,4-DB eq / kg
Soil	(unspecified)	Triazofos	37,4	kg 1,4-DB eq / kg
Soil	agricultural	Triazofos	1190	kg 1,4-DB eq / kg
Air	(unspecified)	Tributyltin oxide	7500	kg 1,4-DB eq / kg
Water	(unspecified)	Tributyltin oxide	3380	kg 1,4-DB eq / kg
Water	ocean	Tributyltin oxide	54,6	kg 1,4-DB eq / kg
Soil	(unspecified)	Tributyltin oxide	42,8	kg 1,4-DB eq / kg
Soil	agricultural	Tributyltin oxide	292	kg 1,4-DB eq / kg
Air	(unspecified)	Trichlorfon	4,45	kg 1,4-DB eq / kg
Water	(unspecified)	Trichlorfon	0,372	kg 1,4-DB eq / kg
Water	ocean	Trichlorfon	0,0000309	kg 1,4-DB eq / kg
Soil	(unspecified)	Trichlorfon	0,0196	kg 1,4-DB eq / kg
Soil	agricultural	Trichlorfon	32,6	kg 1,4-DB eq / kg
Air	(unspecified)	Trifluralin	1,74	kg 1,4-DB eq / kg
Water	(unspecified)	Trifluralin	97	kg 1,4-DB eq / kg
Water	ocean	Trifluralin	6,05	kg 1,4-DB eq / kg
Soil	(unspecified)	Trifluralin	0,682	kg 1,4-DB eq / kg
Soil	agricultural	Trifluralin	125	kg 1,4-DB eq / kg
Water	(unspecified)	Vanadium	3160	kg 1,4-DB eq / kg
Water	ocean	Vanadium	6230	kg 1,4-DB eq / kg
Air	(unspecified)	Vanadium, ion	6240	kg 1,4-DB eq / kg
Soil	(unspecified)	Vanadium, ion	1700	kg 1,4-DB eq / kg
Soil	agricultural	Vanadium, ion	18500	kg 1,4-DB eq / kg
Water	(unspecified)	Zinc	0,584	kg 1,4-DB eq / kg
Water	ocean	Zinc	3,2	kg 1,4-DB eq / kg
Air	(unspecified)	Zinc, ion	104	kg 1,4-DB eq / kg
Soil	(unspecified)	Zinc, ion	0,422	kg 1,4-DB eq / kg
Soil	agricultural	Zinc, ion	63,7	kg 1,4-DB eq / kg
Air	(unspecified)	Zineb	4,76	kg 1,4-DB eq / kg
Water	(unspecified)	Zineb	1,73	kg 1,4-DB eq / kg
Water	ocean	Zineb	0,000821	kg 1,4-DB eq / kg
Soil	(unspecified)	Zineb	0,1	kg 1,4-DB eq / kg
Soil	agricultural	Zineb	20,4	kg 1,4-DB eq / kg

Impact category	Acidification	kg SO2 eq		
Air	(unspecified)	Ammonia	1,6	kg SO2 eq / kg
Air	(unspecified)	Nitric oxide	0,76	kg SO2 eq / kg
Air	(unspecified)	Nitrogen dioxide	0,5	kg SO2 eq / kg
Air	(unspecified)	Nitrogen oxides	0,5	kg SO2 eq / kg
Air	(unspecified)	Sulfur dioxide	1,2	kg SO2 eq / kg
Air	(unspecified)	Sulfur monoxide	1,2	kg SO2 eq / kg
Air	(unspecified)	Sulfur trioxide	0,96	kg SO2 eq / kg
Air	(unspecified)	Sulfuric acid	0,78	kg SO2 eq / kg

Impact category	Eutrophication	kg PO4--- eq		
Air	(unspecified)	Ammonia	0,35	kg PO4--- eq / kg

Water	(unspecified)	Ammonia	0,35	kg PO4--- eq / kg
Soil	(unspecified)	Ammonia	0,35	kg PO4--- eq / kg
Air	(unspecified)	Ammonium, ion	0,33	kg PO4--- eq / kg
Water	(unspecified)	Ammonium, ion	0,33	kg PO4--- eq / kg
Soil	(unspecified)	Ammonium, ion	0,33	kg PO4--- eq / kg
Water	(unspecified)	COD, Chemical Oxygen Demand	0,022	kg PO4--- eq / kg
Air	(unspecified)	Dinitrogen monoxide	0,27	kg PO4--- eq / kg
Air	(unspecified)	Nitrate	0,1	kg PO4--- eq / kg
Water	(unspecified)	Nitrate	0,1	kg PO4--- eq / kg
Soil	(unspecified)	Nitrate	0,1	kg PO4--- eq / kg
Air	(unspecified)	Nitric acid	0,1	kg PO4--- eq / kg
Water	(unspecified)	Nitric acid	0,1	kg PO4--- eq / kg
Soil	(unspecified)	Nitric acid	0,1	kg PO4--- eq / kg
Air	(unspecified)	Nitric oxide	0,2	kg PO4--- eq / kg
Water	(unspecified)	Nitrite	0,1	kg PO4--- eq / kg
Air	(unspecified)	Nitrogen	0,42	kg PO4--- eq / kg
Water	(unspecified)	Nitrogen	0,42	kg PO4--- eq / kg
Soil	(unspecified)	Nitrogen	0,42	kg PO4--- eq / kg
Air	(unspecified)	Nitrogen dioxide	0,13	kg PO4--- eq / kg
Air	(unspecified)	Nitrogen oxides	0,13	kg PO4--- eq / kg
Water	(unspecified)	Nitrogen oxides	0,13	kg PO4--- eq / kg
Soil	(unspecified)	Nitrogen oxides	0,13	kg PO4--- eq / kg
Air	(unspecified)	Nitrogen, total	0,42	kg PO4--- eq / kg
Water	(unspecified)	Nitrogen, total	0,42	kg PO4--- eq / kg
Soil	(unspecified)	Nitrogen, total	0,42	kg PO4--- eq / kg
Air	(unspecified)	Phosphate	1	kg PO4--- eq / kg
Water	(unspecified)	Phosphate	1	kg PO4--- eq / kg
Soil	(unspecified)	Phosphate	1	kg PO4--- eq / kg
Air	(unspecified)	Phosphoric acid	0,97	kg PO4--- eq / kg
Water	(unspecified)	Phosphoric acid	0,97	kg PO4--- eq / kg
Soil	(unspecified)	Phosphoric acid	0,97	kg PO4--- eq / kg
Air	(unspecified)	Phosphorus	3,06	kg PO4--- eq / kg
Water	(unspecified)	Phosphorus	3,06	kg PO4--- eq / kg
Soil	(unspecified)	Phosphorus	3,06	kg PO4--- eq / kg
Air	(unspecified)	Phosphorus pentoxide	1,34	kg PO4--- eq / kg
Water	(unspecified)	Phosphorus pentoxide	1,34	kg PO4--- eq / kg
Soil	(unspecified)	Phosphorus pentoxide	1,34	kg PO4--- eq / kg
Air	(unspecified)	Phosphorus, total	3,06	kg PO4--- eq / kg
Water	(unspecified)	Phosphorus, total	3,06	kg PO4--- eq / kg
Soil	(unspecified)	Phosphorus, total	3,06	kg PO4--- eq / kg

Cumulative Energy Demand V1.08

Method to calculate Cumulative Energy Demand (CED), based on the method published by ecoinvent version 2.0 and expanded by PRé Consultants for raw materials available in the SimaPro 7 database.

Contact info: http://www.ecoinvent.org/contact/

Frischknecht R., Jungbluth N., et.al. (2003). Implementation of Life Cycle Impact Assessment Methods. Final report ecoinvent 2000, Swiss Centre for LCI. Duebendorf, CH, www.ecoinvent.ch

Wood is not included in this methodology due to the frequent use of wood as feedstock in Simapro.

Normalization: it is not a part of this method.

Weighting: Each impact category is given the weighting factor 1.

For more information see the Database manual.

Adaptations (August 2004, v1.01):
Added: Additional oil resources; Water, barrage
Corrected values: Uranium ore, 1.11 GJ per kg, in ground; Uranium, 2291 GJ per kg, in ground; Uranium, 451 GJ per kg, in ground; Uranium, 560 GJ per kg, in ground.
Not included: Energy from hydrogen; Energy, recovered; Energy, unspecified; Oil; Steam from waste incineration.

Other adaptations (March 2005, v1.02):
- Sulphur removed.

Other adaptations (August 2005, v1.03):
- In impact category Non renewable, fossil the characterisation value for "Gas, natural in ground" has been changed from 40,3 to 38.3 MJ LHV/m3 following the ecoinvent 1.2 update.

Other adaptations (February 2008, v1.04):
- Minor adaptations in Unit names and Impact category names (capitals, points) for more consistency with other categories.

Other adaptations (April 2008, v1.05):
- Seven extra substance flows are added:
    Energy, gross calorific value, in biomas, primary forest'
    Geothermal converted'
    Energy, solar, converted'
    Energy, from hydrogen'
    Energy, unspecified'
- The characterisation factor of Peat, in ground' raw biotic in IC non renewable, fossil has a new characterisation factor = 9

Other adaptations (November 2009, v1.06):
- Created a new impact category: 'Non-renewable, biomass' and moved the substance 'energy, gross calorific value, in biomass, primairy forest' to this new impact category.

Other adaptations (March 2010, v1.07):
Weighting: The weighting factor of impact category non-renewable biomass was changed to 1

Other adaptations (August 2010, v1.08):
The quantity and unit of the single score is changed:
v1.07: Indicator (Pt)
v1.08: Energy (MJ)

Impact category	Non renewable, fossil	MJ		
Raw	(unspecified)	Coal, 18 MJ per kg	18	MJ / kg
Raw	(unspecified)	Coal, 26.4 MJ per kg	26,4	MJ / kg
Raw	(unspecified)	Coal, 29.3 MJ per kg	29,3	MJ / kg
Raw	(unspecified)	Coal, brown	9,9	MJ / kg
Raw	(unspecified)	Coal, brown, 10 MJ per kg	10	MJ / kg
Raw	(unspecified)	Coal, brown, 8 MJ per kg	8	MJ / kg
Raw	(unspecified)	Coal, feedstock, 26.4 MJ per kg	26,4	MJ / kg
Raw	(unspecified)	Coal, hard	19,1	MJ / kg
Raw	(unspecified)	Energy, from coal	1	MJ / MJ
Raw	(unspecified)	Energy, from coal, brown	1	MJ / MJ
Raw	(unspecified)	Energy, from gas, natural	1	MJ / MJ
Raw	(unspecified)	Energy, from oil	1	MJ / MJ
Raw	(unspecified)	Energy, from peat	1	MJ / MJ
Raw	(unspecified)	Energy, from sulfur	1	MJ / MJ
Raw	(unspecified)	Energy, unspecified	1	MJ / MJ
Raw	(unspecified)	Gas, mine, off-gas, process, coal mining/kg	49,8	MJ / kg
Raw	(unspecified)	Gas, mine, off-gas, process, coal mining/m3	39,8	MJ / m3
Raw	(unspecified)	Gas, natural, 30.3 MJ per kg	30,3	MJ / kg
Raw	(unspecified)	Gas, natural, 35 MJ per m3	35	MJ / m3
Raw	(unspecified)	Gas, natural, 36.6 MJ per m3	36,6	MJ / m3
Raw	(unspecified)	Gas, natural, 46.8 MJ per kg	46,8	MJ / kg
Raw	(unspecified)	Gas, natural, feedstock, 35 MJ per m3	35	MJ / m3
Raw	(unspecified)	Gas, natural, feedstock, 46.8 MJ per kg	46,8	MJ / kg
Raw	(unspecified)	Gas, natural/m3	38,3	MJ / m3
Raw	(unspecified)	Gas, off-gas, oil production	39,8	MJ / m3
Raw	(unspecified)	Gas, petroleum, 35 MJ per m3	35	MJ / m3
Raw	(unspecified)	Methane	35,9	MJ / kg
Raw	(unspecified)	Oil, crude	45,8	MJ / kg
Raw	(unspecified)	Oil, crude, 38400 MJ per m3	38400	MJ / m3
Raw	(unspecified)	Oil, crude, 41 MJ per kg	41	MJ / kg
Raw	(unspecified)	Oil, crude, 42 MJ per kg	42	MJ / kg
Raw	(unspecified)	Oil, crude, 42.6 MJ per kg	42,6	MJ / kg
Raw	(unspecified)	Oil, crude, 42.7 MJ per kg	42,7	MJ / kg
Raw	(unspecified)	Oil, crude, feedstock, 41 MJ per kg	41	MJ / kg
Raw	(unspecified)	Oil, crude, feedstock, 42 MJ per kg	42	MJ / kg
Raw	(unspecified)	Peat	13	MJ / kg
Raw	biotic	Peat	9	MJ / kg

Impact category	Non-renewable, nuclear	MJ		
Raw	(unspecified)	Energy, from uranium	1	MJ / MJ
Raw	(unspecified)	Uranium	560000	MJ / kg
Raw	(unspecified)	Uranium ore, 1.11 GJ per kg	1110	MJ / kg
Raw	(unspecified)	Uranium, 2291 GJ per kg	2291000	MJ / kg
Raw	(unspecified)	Uranium, 451 GJ per kg	451000	MJ / kg
Raw	(unspecified)	Uranium, 560 GJ per kg	560000	MJ / kg

Impact category	Non-renewable, biomass	MJ		
Raw	(unspecified)	Energy, gross calorific value, in biomass, primary forest	1	MJ / MJ

Impact category	Renewable, biomass	MJ		
Raw	(unspecified)	Biomass, feedstock	1	MJ / MJ
Raw	(unspecified)	Energy, from biomass	1	MJ / MJ
Raw	(unspecified)	Energy, from wood	1	MJ / MJ
Raw	(unspecified)	Energy, gross calorific value, in biomass	1	MJ / MJ

Impact category	Renewable, wind, solar, geothe	MJ		
Raw	(unspecified)	Energy, geothermal	1	MJ / MJ
Raw	(unspecified)	Energy, geothermal, converted	1	MJ / MJ
Raw	(unspecified)	Energy, kinetic (in wind), converted	1	MJ / MJ
Raw	(unspecified)	Energy, solar, converted	1	MJ / MJ

Impact category	Renewable, water	MJ		
Raw	(unspecified)	Energy, from hydro power	1	MJ / MJ
Raw	(unspecified)	Energy, from hydrogen	1	MJ / MJ
Raw	(unspecified)	Energy, potential (in hydropower reservoir), converted	1	MJ / MJ
Raw	(unspecified)	Water, barrage	0,01	MJ / kg

EDIP 2003 V1.04

EDIP2003 is a Danish LCA methodology that is presented as an alternative to the EDIP97 methodology. The EDIP2003 version is adapted for SimaPro.

Contact info: http://www.lca-center.dk/cms/site.aspx?p=4441

The main innovation of EDIP2003 lies in the consistent attempt to include exposure in the characterisation modelling of the main non-global impact categories. EDIP2003 can originally be used both with and without spatial differentiation. Only characterisation factor for site-generic effects, which does not take spatial variation into account, are implemented in SimaPro.

The EDIP2003 methodology represents 18 different impact categories. Some of them are directly taken from EDIP97, some are updated versions of EDIP97, whereas others are modelled totally different. The table underneath gives an overview of the EDIP2003 impact categories. The choices made for implementing the methodology into SimaPro 7.0, are summed up for each impact category

Impact categories:	Implemented in original form	Choices made during implementation
Global warming		Time horizon of 100 years is used and extended with extra factors from EI 2.0
Ozone depletion	x	
Acidification	x	
Terrestrial eutrophication	x	
Aquatic eutrophication (N-eq)		Only emissions to inland waters are included. Emissions to air included
Aquatic eutrophication (P-eq)		
Ozone formation (human)	x	Extended with extra factors from EI 2.0
Ozone formation (vegetation)	x	Extended with extra factors from EI 2.0
Human toxicity (exposure route via air)		Release height of 25m
Human toxicity (exposure route via water)	x	
Human toxicity (exposure route via soil)	x	
Ecotoxicity (water acute)	x	
Ecotoxicity (water chronic)	x	
Ecotoxicity (soil chronic)	x	
Resources		Taken directly from EDIP 97 (updated in 2004)
Waste		Taken directly from EDIP 97 (updated in 2004)

In the EDIP 2003 method, characterisation factors for aquatic eutrophication are developed for two impact categories: Aquatic eutrophication EP(N) and Aquatic eutrophication EP(P). In each impact category, characterisation factors for emissions effecting inland waters and emissions effecting marine waters are developed. This double set of characterisation factors reflect the fact that, in general, eutrophication is limited by Nitrate in fresh waters, and Phosphate in marine waters.
In order to avoid double counting, that would occur if both emission types are implemented simultaneously, only the characterisation factors for inland water are

implemented in SimaPro 7.0. When characterisation factors for marine water are needed, see guidline EDIP 2003 or database manual.

The emission to soil only takes into account the effects after plant uptake. For this impact category the topsoil is part of the techno sphere.
Emission to air are also included in the model. The data needed for this compartment is not present in the guideline, but is received from Michael Hauschild.

The EDIP2003 characterisation factors for human toxicity, exposure route via air, are enhanced. The new exposure factors are established for:
- Two different kinds of substances: short-living (hydrogen chloride) and long-living (benzene)
- Actual variation in regional and local population densities: added for each substance
- Different release heights: 1m, 25m and 100m.
The release height of 25m is presented as default in EDIP2003 and is used in SimaPro 7.0.

For global warming a time horizon of 100 years is recommended by EDIP2003 and is used in SimaPro 7.0.

In the impact categories "ozone formation", for the substance isobutene, two synonyms with the same cas-number and a different characterisation factor are found. Next characterisation factors are used: Ozone formation (human): Isobutene: 9,44E-05
Ozone formation (vegetation): Isobutene: 1,168

The impact category resources is not mentioned and considered in EDIP2003. For calculating effects of within this impact category, the method EDIP/UMP 97 (resources only), available in SimaPro 7.0, can be used. The impact categories waste are directly taken from EDIP 1997 (with updated factors from 2004).

Normalisation:
Except for ecotoxicity, all the different impact categories are normalized in the same way as in EDIP97, only using EDIP2003 normalisation references. Due to lack of data, no EDIP2003 normalisation references for any of the ecotoxicity categories is calculated. Therefore, in SimaPro, the normalisation reference for ecotoxicity is zero.
For the impact categories waste normalization factors of EDIP 1997 are used.

Weighting:
The weighting factors of EDIP97, which were updated in 2004, are also used in EDIP2003. Because ecotoxicity has no normalisation factors, also for weighting the value is zero. For the impact categories waste weighting factors of EDIP 1997 (with updated factors from 2004) are used.

For more information see the Database manual.

Reference:
M. Hauschild and Potting, J., 2003.Spatial differentiation in Life Cycle impact assessment - The EDIP2003 methodology. Institute for Product Development Technical University of Denmark.

Other adaptations (February 2008, v1.00):
- The name of impact category global warming (GWP100) was changed to Global warming 100a
- Expanded with extra substances.

- The folowing "substances" were removed from the method because they were not compatible with the SimaPro substance list:

Chemical cleaning of clothes
Coal mining
Combustion of wood
Diesel-powered car, exhaust
EP-2 syre
Farming
Food industry
Iso MP-1 syre
Landfilling household waste
Petrol-powered car, exhaust
Petrol-powered car, vapour
Power plants
Refining and distribution of oil
Surface coating

Other adaptation (April 2008, v1.01):
-The impact category 'Global warming 100a' is adapted.
The substance 'carbon dioxide, in air' is added, with the negative characterisation factor of carbon dioxide.
The substance 'carbon dioxide, land transformation' is added, with the same characterisation factor of 'carbon dioxide'.
- The characterisation factors for resources were updated according to the update of EDIP97 issued in 2004. Except for Cerium and Lanthanum.
- The normalisation (1994) and weighting (2004) factors for all categories were updated according to the update of EDIP97 issued in 2004.
- Added the substances: Uranium, Chromium, Selenium, Strontium, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium.
- For PGM the average CF of platinum and palladium is used.

Other adaptations (November 2009, v 1.02)
The use of biogenic CO2 has been revised:
- 'carbon dioxide, in air' in global warming (Global warming 100a) has been removed
- 'carbon dioxide, biogenic' in global warming (Global warming 100a) has been removed
- 'carbon mono oxide, biogenic' in global warming (Global warming 100a) has been removed
- Characterization factor of 'Methane, biogenic' in global warming 100a changed from 23 to 20

Other adaptations (July 2011, v 1.03):
- The normalization factor for 'Radioactive waste' with normalization reference equal to 0.16 kg/person/yr was corrected to 6.25.
- The normalization factors for all impact categories were updated. Reference: Laurent A., Olsen S., Hauschild M., 2011. Normalization in EDIP97 and EDIP2003: updated European inventory for 2004 and guidance towards a consistent use in practice. Int J LCA 16, pp.401-409.
- The indicator of resource depletion in EDIP2003 relates the consumption of a given resource in your system (kg-res/f.u.) to the total known reserves per person (kg-res/pers) for that resource in a reference year, here 2004. The characterization factors for this impact category shall be expressed in PR2004/(kg-resource or m3), where PR2004 are Person-Reserves based on the consumption in 2004.
- Characterization unit for "Human toxicity via air" (m3) was replaced by "person".

Other adaptations (October 2013, v 1.04):
- Added Phosphorus, total in the impact category Aquatic eutrophication EP(P).
- Global warming 100a: the GWP100 characterisation factors were replaced by the most recent (IPCC, 2007).
- Added some missing mineral resource flow synonyms.

Impact category	Hazardous waste	kg		
Waste	(unspecified)	Asbestos	1	kg / kg
Waste	(unspecified)	Bilge oil	1	kg / kg
Waste	(unspecified)	Chemical waste, inert	1	kg / kg
Waste	(unspecified)	Chemical waste, regulated	1	kg / kg
Waste	(unspecified)	Chemical waste, unspecified	1	kg / kg
Waste	(unspecified)	Electrostatic filter dust	1	kg / kg
Waste	(unspecified)	Oil separator sludge	1	kg / kg
Waste	(unspecified)	Oil waste	1	kg / kg
Waste	(unspecified)	Refinery sludge	1	kg / kg
Raw	(unspecified)	Volume occupied, underground deposit	1600	kg / m3
Waste	(unspecified)	Waste, from incinerator	1	kg / kg
Waste	(unspecified)	Waste, toxic	1	kg / kg
Waste	(unspecified)	Welding dust	1	kg / kg

Impact category	Radioactive waste	kg		
Raw	(unspecified)	Volume occupied, final repository for low-active radioactive waste	2500	kg / m3
Raw	(unspecified)	Volume occupied, final repository for radioactive waste	5400	kg / m3
Waste	(unspecified)	Waste, nuclear, unspecified/kg	1	kg / kg

EPD (2008) V1.04

This method is to be used for the creation of Environmental Product Declarations or (EPDs), as published on the website Swedish Environmental Management Council (SEMC) www.environdec.com. The original document is titled: "Introduction, intended uses and key programme elements for Environmental Product Declarations, EPD" of 29/02/2008

Contact info: http://www.environdec.com/

In the standard EPDs one only has to report on the following impact categories. Specific product category guidelines may require extra information.
- Gross Calorific Values (GCV) (also referred to as the "Higher Heating Values")
- Greenhouse gases
- Ozone-depleting gases
- Acidifying compounds
- Gases creating ground-level ozone (Photochemical Ozone creation)
- Eutrophicating compounds

Except for the Gross Calorific Value (GVC) impact categories, all impact categories are taken directly from the CML 2 baseline 2000 method, also found in SimaPro (we used release 2.03).

Please note that there are some differences between the SimaPro implementation and the EPD document for the Gross Calorific Values. See the methods section in the Database manuals (available under the Help menu)

For further information see the database manual.

Acknowledgement: We thank Leo Breedveld from 2B (www.to-be.it) for his advise and support.

Mark Goedkoop, June 2007

Other adaptations (February 2008, v1.01):
- Minor adaptations in Unit names and Impact category names (capitals, points) for more consistency with other categories.

Other adaptation (April 2008, v1.02)
- The impact category 'Global warming (GWP100)' is adapted. The substance 'carbon dioxide, land transformation' is added, with the same characterisation factor of 'carbon dioxide'.

Other adaptations (November 2009, v 1.03)
Global warming:
The use of biogenic CO2 has been revised:
- 'carbon dioxide, in air' in global warming (Global warming (GWP100)) has been removed
- 'carbon dioxide, biogenic' in global warming (Global warming (GWP100)) has been removed
- 'carbon mono oxide, biogenic' in global warming (Global warming (GWP100)) has been removed
- Characterization factor of 'Methane, biogenic' in global warming (GWP100) changed from 23 to 20

The method is addapted to align the method with the document released by The international EPD cooperation (IEC) (version 1.0 dated 2008-02-29). The following issues were changed:

Global warming:
The substance list has been adapted to the official EPD source. Only the substances with a common name are implemented, the substances with only a molecular formula are not implemented.
The characterization factor of carbon monoxide is changed from 1.53 to 1.57.

Ozone depletion (ODP):
The substance list has been adapted to the official EPD source.

Photochemical oxidation (POCP):
Changed the characterisation factor of NMVOC from 0.46 to 1 according to official EPD source.

Acidification:
Changed the characterisation factor of Sulphur dioxide and sulphur oxides from 1.2 to 1.

Eutrophication:
Added characterisation factor for Dinitrogen monoxide of 0.13
Added characterisation factor for Nitrogen of 0.42

Non renewable, fossil
The characterisation values of the cumulative energy demand (upper heating value) are used for this impact category.

Other adaptations (November 2012, v1.04)
- Global warming: the GWP100 characterisation factors were replaced by the most recent (IPCC, 2007).

Impact category	Ozone layer depletion (ODP)	kg CFC-11 eq		
Air	(unspecified)	Ethane, 1-chloro-1,1-difluoro-, HCFC-142b	0,14	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	0,33	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	0,45	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	0,59	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,2-dibromotetrafluoro-, Halon 2402	11	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	0,08	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	0,08	kg CFC-11 eq / kg
Air	(unspecified)	Methane, bromochlorodifluoro-, Halon 1211	9	kg CFC-11 eq / kg
Air	(unspecified)	Methane, bromotrifluoro-, Halon 1301	10,5	kg CFC-11 eq / kg
Air	(unspecified)	Methane, chlorodifluoro-, HCFC-22	0,14	kg CFC-11 eq / kg
Air	(unspecified)	Methane, tetrachloro-, CFC-10	1,23	kg CFC-11 eq / kg
Air	(unspecified)	Methane, trichlorofluoro-, CFC-11	1	kg CFC-11 eq / kg
Air	(unspecified)	Propane, 1,3-dichloro-1,1,2,2,3-pentafluoro-, HCFC-225cb	0,11	kg CFC-11 eq / kg
Air	(unspecified)	Propane, 3,3-dichloro-1,1,1,2,2-pentafluoro-, HCFC-225ca	0,1	kg CFC-11 eq / kg

Impact category	Photochemical oxidation	kg C2H4 eq		
Air	(unspecified)	1-Butanol	0,62	kg C2H4 eq / kg
Air	(unspecified)	1-Butene	1,079	kg C2H4 eq / kg
Air	(unspecified)	1-Butene, 2-methyl-	0,771	kg C2H4 eq / kg
Air	(unspecified)	1-Butene, 3-methyl-	0,671	kg C2H4 eq / kg
Air	(unspecified)	1-Hexene	0,874	kg C2H4 eq / kg
Air	(unspecified)	1-Pentene	0,977	kg C2H4 eq / kg
Air	(unspecified)	1-Propanol	0,561	kg C2H4 eq / kg
Air	(unspecified)	2-Butanol	0,4	kg C2H4 eq / kg
Air	(unspecified)	2-Butanone, 3-methyl-	0,364	kg C2H4 eq / kg
Air	(unspecified)	2-Butene (cis)	1,146	kg C2H4 eq / kg
Air	(unspecified)	2-Butene (trans)	1,132	kg C2H4 eq / kg
Air	(unspecified)	2-Butene, 2-methyl-	0,842	kg C2H4 eq / kg
Air	(unspecified)	2-Hexanone	0,572	kg C2H4 eq / kg
Air	(unspecified)	2-Hexene (cis)	1,069	kg C2H4 eq / kg
Air	(unspecified)	2-Hexene (trans)	1,073	kg C2H4 eq / kg
Air	(unspecified)	2-Methyl-1-propanol	0,36	kg C2H4 eq / kg
Air	(unspecified)	2-Methyl-2-butanol	0,228	kg C2H4 eq / kg
Air	(unspecified)	2-Pentanone	0,548	kg C2H4 eq / kg
Air	(unspecified)	2-Pentene (cis)	1,121	kg C2H4 eq / kg
Air	(unspecified)	2-Pentene (trans)	1,117	kg C2H4 eq / kg
Air	(unspecified)	2-Propanol	0,188	kg C2H4 eq / kg
Air	(unspecified)	3-Hexanone	0,599	kg C2H4 eq / kg
Air	(unspecified)	3-Methyl-1-butanol	0,433	kg C2H4 eq / kg
Air	(unspecified)	3-Pentanol	0,595	kg C2H4 eq / kg
Air	(unspecified)	3-Pentanone	0,414	kg C2H4 eq / kg
Air	(unspecified)	3,3-Dimethyl-2-butanone	0,323	kg C2H4 eq / kg
Air	(unspecified)	4-Hydroxy-4-methyl-2-pentanone	0,307	kg C2H4 eq / kg
Air	(unspecified)	4-Methyl-2-pentanone	0,49	kg C2H4 eq / kg
Air	(unspecified)	Acetaldehyde	0,641	kg C2H4 eq / kg
Air	(unspecified)	Acetic acid	0,097	kg C2H4 eq / kg
Air	(unspecified)	Acetone	0,094	kg C2H4 eq / kg
Air	(unspecified)	Benzaldehyde	-0,092	kg C2H4 eq / kg
Air	(unspecified)	Benzene	0,218	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 1,2,3-trimethyl-	1,267	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 1,2,4-trimethyl-	1,278	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 1,3,5-trimethyl-	1,381	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 3,5-dimethylethyl-	1,32	kg C2H4 eq / kg
Air	(unspecified)	Benzene, ethyl-	0,73	kg C2H4 eq / kg
Air	(unspecified)	Butadiene	0,851	kg C2H4 eq / kg
Air	(unspecified)	Butanal	0,795	kg C2H4 eq / kg
Air	(unspecified)	Butane	0,352	kg C2H4 eq / kg
Air	(unspecified)	Butane, 2,2-dimethyl-	0,241	kg C2H4 eq / kg
Air	(unspecified)	Butane, 2,3-dimethyl-	0,541	kg C2H4 eq / kg
Air	(unspecified)	Butanol, 2-methyl-1-	0,489	kg C2H4 eq / kg
Air	(unspecified)	Butanol, 3-methyl-2-	0,406	kg C2H4 eq / kg
Air	(unspecified)	Butyl acetate	0,269	kg C2H4 eq / kg
Air	(unspecified)	Carbon monoxide	0,027	kg C2H4 eq / kg
Air	(unspecified)	Carbon monoxide, biogenic	0,027	kg C2H4 eq / kg
Air	(unspecified)	Carbon monoxide, fossil	0,027	kg C2H4 eq / kg
Air	(unspecified)	Chloroform	0,023	kg C2H4 eq / kg
Air	(unspecified)	Cumene	0,5	kg C2H4 eq / kg
Air	(unspecified)	Cyclohexane	0,29	kg C2H4 eq / kg
Air	(unspecified)	Cyclohexanol	0,518	kg C2H4 eq / kg
Air	(unspecified)	Cyclohexanone	0,299	kg C2H4 eq / kg
Air	(unspecified)	Decane	0,384	kg C2H4 eq / kg
Air	(unspecified)	Diethyl ether	0,445	kg C2H4 eq / kg
Air	(unspecified)	Diisopropyl ether	0,398	kg C2H4 eq / kg
Air	(unspecified)	Dimethyl carbonate	0,025	kg C2H4 eq / kg
Air	(unspecified)	Dimethyl ether	0,189	kg C2H4 eq / kg
Air	(unspecified)	Dodecane	0,357	kg C2H4 eq / kg

Air	(unspecified)	Ethane	0,123	kg C2H4 eq / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	0,009	kg C2H4 eq / kg
Air	(unspecified)	Ethanol	0,399	kg C2H4 eq / kg
Air	(unspecified)	Ethanol, 2-butoxy-	0,483	kg C2H4 eq / kg
Air	(unspecified)	Ethanol, 2-ethoxy-	0,386	kg C2H4 eq / kg
Air	(unspecified)	Ethanol, 2-methoxy-	0,307	kg C2H4 eq / kg
Air	(unspecified)	Ethene	1	kg C2H4 eq / kg
Air	(unspecified)	Ethene, dichloro- (cis)	0,447	kg C2H4 eq / kg
Air	(unspecified)	Ethene, dichloro- (trans)	0,392	kg C2H4 eq / kg
Air	(unspecified)	Ethene, tetrachloro-	0,029	kg C2H4 eq / kg
Air	(unspecified)	Ethene, trichloro-	0,325	kg C2H4 eq / kg
Air	(unspecified)	Ethyl acetate	0,209	kg C2H4 eq / kg
Air	(unspecified)	Ethylene glycol	0,373	kg C2H4 eq / kg
Air	(unspecified)	Ethyne	0,085	kg C2H4 eq / kg
Air	(unspecified)	Formaldehyde	0,519	kg C2H4 eq / kg
Air	(unspecified)	Formic acid	0,032	kg C2H4 eq / kg
Air	(unspecified)	Heptane	0,494	kg C2H4 eq / kg
Air	(unspecified)	Hexane	0,482	kg C2H4 eq / kg
Air	(unspecified)	Hexane, 2-methyl-	0,411	kg C2H4 eq / kg
Air	(unspecified)	Hexane, 3-methyl-	0,364	kg C2H4 eq / kg
Air	(unspecified)	Hydrocarbons, unspecified	0,337	kg C2H4 eq / kg
Air	(unspecified)	Isobutane	0,307	kg C2H4 eq / kg
Air	(unspecified)	Isobutene	0,627	kg C2H4 eq / kg
Air	(unspecified)	Isobutyraldehyde	0,514	kg C2H4 eq / kg
Air	(unspecified)	Isopentane	0,405	kg C2H4 eq / kg
Air	(unspecified)	Isoprene	1,092	kg C2H4 eq / kg
Air	(unspecified)	Isopropyl acetate	0,211	kg C2H4 eq / kg
Air	(unspecified)	m-Xylene	1,108	kg C2H4 eq / kg
Air	(unspecified)	Methane	0,006	kg C2H4 eq / kg
Air	(unspecified)	Methane, biogenic	0,006	kg C2H4 eq / kg
Air	(unspecified)	Methane, dichloro-, HCC-30	0,068	kg C2H4 eq / kg
Air	(unspecified)	Methane, dimethoxy-	0,164	kg C2H4 eq / kg
Air	(unspecified)	Methane, fossil	0,006	kg C2H4 eq / kg
Air	(unspecified)	Methane, monochloro-, R-40	0,005	kg C2H4 eq / kg
Air	(unspecified)	Methanol	0,14	kg C2H4 eq / kg
Air	(unspecified)	Methyl acetate	0,059	kg C2H4 eq / kg
Air	(unspecified)	Methyl ethyl ketone	0,373	kg C2H4 eq / kg
Air	(unspecified)	Methyl formate	0,027	kg C2H4 eq / kg
Air	(unspecified)	N-octane	0,453	kg C2H4 eq / kg
Air	(unspecified)	N-propylbenzene	0,636	kg C2H4 eq / kg
Air	(unspecified)	Nitric oxide	-0,427	kg C2H4 eq / kg
Air	(unspecified)	Nitrogen dioxide	0,028	kg C2H4 eq / kg
Air	(unspecified)	NMVOC, non-methane volatile organic compounds, unspecified origin	1	kg C2H4 eq / kg
Air	(unspecified)	Nonane	0,414	kg C2H4 eq / kg
Air	(unspecified)	o-Xylene	1,053	kg C2H4 eq / kg
Air	(unspecified)	p-Xylene	1,01	kg C2H4 eq / kg
Air	(unspecified)	Pentanal	0,765	kg C2H4 eq / kg
Air	(unspecified)	Pentane	0,395	kg C2H4 eq / kg
Air	(unspecified)	Pentane, 2-methyl-	0,42	kg C2H4 eq / kg
Air	(unspecified)	Pentane, 3-methyl-	0,479	kg C2H4 eq / kg
Air	(unspecified)	Petrol	0,42	kg C2H4 eq / kg
Air	(unspecified)	Propanal	0,798	kg C2H4 eq / kg
Air	(unspecified)	Propane	0,176	kg C2H4 eq / kg
Air	(unspecified)	Propane, 2,2-dimethyl-	0,173	kg C2H4 eq / kg
Air	(unspecified)	Propene	1,123	kg C2H4 eq / kg
Air	(unspecified)	Propionic acid	0,15	kg C2H4 eq / kg
Air	(unspecified)	Propyl acetate	0,282	kg C2H4 eq / kg
Air	(unspecified)	Propylene glycol	0,457	kg C2H4 eq / kg
Air	(unspecified)	Propylene glycol methyl ether	0,355	kg C2H4 eq / kg
Air	(unspecified)	Propylene glycol t-butyl ether	0,463	kg C2H4 eq / kg
Air	(unspecified)	s-Butyl acetate	0,275	kg C2H4 eq / kg
Air	(unspecified)	Styrene	0,142	kg C2H4 eq / kg
Air	(unspecified)	Sulfur dioxide	0,048	kg C2H4 eq / kg
Air	(unspecified)	Sulfur monoxide	0,048	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl acetate	0,053	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl alcohol	0,106	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl ethyl ether	0,244	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl methyl ether	0,175	kg C2H4 eq / kg
Air	(unspecified)	Toluene	0,637	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 2-ethyl-	0,898	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 3-ethyl-	1,019	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 3,5-diethyl-	1,295	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 4-ethyl-	0,906	kg C2H4 eq / kg
Air	(unspecified)	Undecane	0,384	kg C2H4 eq / kg

ILCD 2011 Midpoint V1.02

The ILCD 2011 Midpoint method was released by the European Commission, Joint Research Centre in 2012. It supports the correct use of the characterisation factors for impact assessment as recommended in the ILCD guidance document "Recommendations for Life Cycle Impact Assessment in the European context - based on existing environmental impact assessment models and factors? (EC-JRC, 2011)".

Reference:
European Commission, Joint Research Centre, Institute for Environment and Sustainability. Characterisation factors of the ILCD Recommended Life Cycle Impact Assessment methods. Database and Supporting Information. First edition. February 2012. EUR 25167. Luxembourg. Publications Office of the European Union; 2012.

This LCIA method includes 16 midpoint impact categories:
1 - Climate change: Global Warming Potential calculating the radiative forcing over a time horizon of 100 years. | IPCC 2007.
2 - Ozone depletion: Ozone Depletion Potential (ODP) calculating the destructive effects on the stratospheric ozone layer over a time horizon of 100 years. | World Meteorological Organization (WMO) 1999.
3 - Human toxicity, cancer effects: Comparative Toxic Unit for humans (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme). Specific groups of chemicals requires further works. | USEtox.
4 - Human toxicity, non-cancer effects: Comparative Toxic Unit for humans (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme). Specific groups of chemicals requires further works. | USEtox.
5 - Particulate matter: Quantification of the impact of premature death or disability that particulates/respiratory inorganics have on the population, in comparison to PM2.5. It includes the assessment of primary (PM10 and PM2.5) and secondary PM (incl. creation of secondary PM due to SOx, NOx and NH3 emissions) and CO. | Rabl and Spadaro 2004.
6 - Ionizing radiation HH (human health): Quantification of the impact of ionizing radiation on the population, in comparison to Uranium 235. | Frischknecht et al. 2000.
7 - Ionizing radiation E (ecosystems) [note: this method is classified as interim; see reference for explanation]: Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a radionucleide emitted (PAF m3 year/kg). Fate of radionucleide based on USEtox consensus model (multimedia model). Relevant for freshwater ecosystems. | Garnier-Laplace et al. 2008.
8 - Photochemical ozone formation: Expression of the potential contribution to photochemical ozone formation. Only for Europe. It includes spatial differentiation | van Zelm et al. 2008.
9 - Acidification: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area in terrestrial and main freshwater ecosystems, to which acidifying substances deposit. European-country dependent. | Seppälä et al. 2006 and Posch et al. 2008.
10 - Terrestrial eutrophication: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area, to which eutrophying substances deposit. European-country dependent. | Seppälä et al. 2006 and Posch et al. 2008.
11 - Freshwater eutrophication: Expression of the degree to which the emitted nutrients reaches the freshwater end compartment (phosphorus considered as limiting factor in

freshwater). European validity. Averaged characterization factors from country dependent characterization factors. | ReCiPe version 1.05.
12 - Marine eutrophication: Expression of the degree to which the emitted nutrients reaches the marine end compartment (nitrogen considered as limiting factor in marine water). European validity. Averaged characterization factors from country dependent characterization factors. | ReCiPe version 1.05.
13 - Freshwater ecotoxicity: Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a chemical emitted (PAF m3 year/kg). Specific groups of chemicals requires further works. | USEtox.
14 - Land use: Soil Organic Matter (SOM) based on changes in SOM, measured in (kg C/m2/a). Biodiversity impacts not covered by the data set. | Mila i Canals et al. 2007.
15 - Water resource depletion: Freshwater scarcity: Scarcity-adjusted amount of water used. | Swiss Ecoscarcity 2006.
16 - Mineral, fossil & renewable resource depletion: Scarcity of mineral resource with the scarcity calculated as 'Reserve base'. It refers to identified resources that meets specified minimum physical and chemical criteria related to current mining practice. The reserve base may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. | van Oers et al. 2002.

Implemented in SimaPro by PRé Consultants.

Adaptations implemented (June 2012):
- To ensure the balance of carbon uptake and biogenic emissions if end of life is not included, the characterization factors for these substances have been corrected.
- Added characterization factors for Nitrogen oxides - NOx - emissions (to air) in the impact categories Particulate matter, Acidification, Terrestrial eutrophication, and Marine eutrophication as equal to those of Nitrogen dioxide (to air).

Other adaptations (Version 1.01, September 2012):
- The characterisation factors of the impact category 'Water resource depletion' are based on the ecological scarcity method (2006), but are recalculated by JRC to express these in the unit of "m3 water eq" instead of "EP" (the unit used in the previous version). The calculations are approved by the developers of the ecological scarcity method.
- Units of the impact categories 'Freshwater eutrophication' and 'Marine eutrophication' were corrected from 'molc P eq' to 'kg P eq' and 'molc N eq' to 'kg N eq', respectively.
- The substance Nitrogen monoxide (CAS nr. 175876-44-5) was replaced by Nitric oxide (CAS nr. 010102-43-9).
- The characterisation factor of Gas, natural/m3 for the impact category Mineral, fossil & renewable resource depletion was corrected to 2.78E-07 kg Sb eq/m3 assuming an average density of 0.81 kg/m3. The characterisation factor of Uranium for this impact category was corrected to 0.195 kg Sb/kg and the characterisation factors for Gallium and Magnesium were added.
- Characterization factors of impact categories 'Human health, cancer effects', 'Human health, non-cancer effects' and Ionising radiation E (interim) were corrected for errors due to incorrect decimal separation.
- The characterisation factor for the substance 'Particulates, <2.5 um' in impact category 'Particulate matter', compartment 'Air', 'High population' was corrected for an error of a factor 1 000 000 000 too high.
- Please note that the characterisation factors for Nitrogen dioxide and Nitrogen oxides in 'Marine eutrophication' were corrected from 0.389 to 0.039 kg N eq/kg in ReCiPe version 1.06, but the impact categories from ReCiPe in this method (ILCD 2011 Midpoint version 1.01) are based on ReCiPe version 1.05. So, they are not corrected here.

- Some substance names and CAS numbers in the impact categories 'Freshwater ecotoxicity', 'Human health, cancer effects', and 'Human health, non-cancer effects' were mismatched.
These following substance names were corrected, because of wrong names in ILCD:
CAS number - Wrong name used in ILCD -> Correct name used in SimaPro
091465-08-6 - Cyhalothrin -> Lambda-cyhalothrin
028434-00-6 - Pyrethrin -> Trans-(+)-allethrin
008003-34-7 - Pyrethrin -> Pyrethrum
001910-42-5 - Paraquat -> Paraquat dichloride
000091-22-5 - Aldicarb -> Quinoline
027458-94-2 - Isononyl alcohol -> Isononanol
003653-48-3 - MCPA -> MCPA - sodium salt

The following substance names were corrected, because synonyms exist with different CAS numbers and characterisation factors (!):
CAS number - Name used in ILCD -> Name used in SimaPro
064257-84-7 - Fenpropathrin -> [Cyano-[3-(phenoxy)phenyl]methyl] 2,2,3,3-tetramethylcyclopropane-1-carboxylate
022248-79-9 - Tetrachlorvinphos -> Tetrachlorvinphos ((Z)-isomer)
113096-99-4 - Cyproconazole -> 2-(4-Chlorophenyl)-3-cyclopropyl-1-(1,2,4-triazol-1-yl)butan-2-ol
004170-30-3 - Crotonaldehyde -> 2-Butenal
007085-19-0 - Mecoprop -> 2-(4-Chloro-2-methylphenoxy)propanoic acid
072490-01-8 - Fenoxycarb -> Ethyl 2-(4-phenoxyphenoxy)ethylcarbamate

The following substances are the synonyms of the above list with different characterisation factors:
039515-41-8 - Fenpropathrin
000961-11-5 - Rabon -> Tetrachlorvinphos (name used in SimaPro)
094361-06-5 - Cyproconazole
000123-73-9 - Trans-2-butenal -> Crotonaldehyde (name used in SimaPro)
000093-65-2 - Mecoprop
079127-80-3 - Fenoxycarb

Other adaptations (Version 1.02, October 2013):
- Added the substance Phosphorus in Air and Soil in the impact category Freshwater eutrophication
- Added the country and region specific water flows that are missing in the above mentioned reference by converting the factors in the Ecological Scarcity 2006 method with the factor 598 UBP per m3 water equivalents, which is in agreement with the characterization factors that were already present in the ILCD 2011 Midpoint method version 1.02 and the Ecological Scarcity 2006 method.
- Added country and region specific water flows for lake, river, well in ground resources and water to water flows.
- Mineral resource flow synonyms were added to better align with the LCI libraries.
- Added CF for carbon dioxide emissions from land transformation.

Impact category	Mineral, fossil & ren resource depletion	kg Sb eq		
Raw	(unspecified)	Aluminium	0,0000253	kg Sb eq / kg
Raw	(unspecified)	Antimony	1	kg Sb eq / kg
Raw	(unspecified)	Arsenic	2,4	kg Sb eq / kg
Raw	(unspecified)	Barium	0,00337	kg Sb eq / kg
Raw	(unspecified)	Bauxite	0,0000087	kg Sb eq / kg
Raw	(unspecified)	Beryllium	3,95	kg Sb eq / kg
Raw	(unspecified)	Bismuth	4,49	kg Sb eq / kg
Raw	(unspecified)	Boron	0,00528	kg Sb eq / kg
Raw	(unspecified)	Cadmium	1,11	kg Sb eq / kg
Raw	(unspecified)	Carbon, organic, in soil or biomass stock	0,000444	kg Sb eq / kg
Raw	(unspecified)	Cerium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Chromium	0,0000196	kg Sb eq / kg
Raw	(unspecified)	Coal, brown	9,27E-08	kg Sb eq / kg
Raw	(unspecified)	Coal, hard	0,000000205	kg Sb eq / kg
Raw	(unspecified)	Cobalt	0,0256	kg Sb eq / kg
Raw	(unspecified)	Copper	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 0.52% in sulfide, Cu 0.27% and Mo 8.2E-3% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 0.59% in sulfide, Cu 0.22% and Mo 8.2E-3% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 0.97% in sulfide, Cu 0.36% and Mo 4.1E-2% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 0.99% in sulfide, Cu 0.36% and Mo 8.2E-3% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 1.13% in sulfide, Cu 0.76% and Ni 0.76% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 1.18% in sulfide, Cu 0.39% and Mo 8.2E-3% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 1.42% in sulfide, Cu 0.81% and Mo 8.2E-3% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, 2.19% in sulfide, Cu 1.83% and Mo 8.2E-3% in crude ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, Cu 0.38%, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Pb 0.014%, in ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, Cu 3.2E+0%, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0% in ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Copper, Cu 5.2E-2%, Pt 4.8E-4%, Pd 2.0E-4%, Rh 2.4E-5%, Ni 3.7E-2% in ore	0,0025	kg Sb eq / kg
Raw	(unspecified)	Dysprosium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Erbium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Europium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Fluorspar	0,00262	kg Sb eq / kg
Raw	(unspecified)	Gadolinium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Gallium	0,0063	kg Sb eq / kg
Raw	(unspecified)	Garnet, industrial	0,0044	kg Sb eq / kg
Raw	(unspecified)	Gas, natural/m3	0,000000278	kg Sb eq / m3
Raw	(unspecified)	Germanium	19500	kg Sb eq / kg
Raw	(unspecified)	Gold	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 1.1E-4%, Ag 4.2E-3%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 1.3E-4%, Ag 4.6E-5%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 2.1E-4%, Ag 2.1E-4%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 4.3E-4%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 4.9E-5%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 6.7E-4%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 7.1E-4%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Gold, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore	36	kg Sb eq / kg
Raw	(unspecified)	Holmium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Indium	555	kg Sb eq / kg
Raw	(unspecified)	Iodine	0,00222	kg Sb eq / kg
Raw	(unspecified)	Iron	0,00000166	kg Sb eq / kg
Raw	(unspecified)	Lanthanum	0,000569	kg Sb eq / kg
Raw	(unspecified)	Lead	0,015	kg Sb eq / kg
Raw	(unspecified)	Lead, Pb 0.014%, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, in ore	0,015	kg Sb eq / kg
Raw	(unspecified)	Lithium	0,0133	kg Sb eq / kg
Raw	(unspecified)	Lutetium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Magnesium	0,00000248	kg Sb eq / kg
Raw	(unspecified)	Manganese	0,0000235	kg Sb eq / kg
Raw	(unspecified)	Mercury	2,62	kg Sb eq / kg
Raw	(unspecified)	Molybdenum	0,0711	kg Sb eq / kg
Raw	(unspecified)	Molybdenum, 0.010% in sulfide, Mo 8.2E-3% and Cu 1.83% in crude ore	0,0711	kg Sb eq / kg
Raw	(unspecified)	Molybdenum, 0.014% in sulfide, Mo 8.2E-3% and Cu 0.81% in crude ore	0,0711	kg Sb eq / kg
Raw	(unspecified)	Molybdenum, 0.016% in sulfide, Mo 8.2E-3% and Cu 0.27% in crude ore	0,0711	kg Sb eq / kg
Raw	(unspecified)	Molybdenum, 0.022% in sulfide, Mo 8.2E-3% and Cu 0.22% in crude ore	0,0711	kg Sb eq / kg
Raw	(unspecified)	Molybdenum, 0.022% in sulfide, Mo 8.2E-3% and Cu 0.36% in crude ore	0,0711	kg Sb eq / kg
Raw	(unspecified)	Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore	0,0711	kg Sb eq / kg
Raw	(unspecified)	Molybdenum, 0.11% in sulfide, Mo 0.41% and Cu 0.36% in crude ore	0,0711	kg Sb eq / kg
Raw	(unspecified)	Neodymium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Nickel	0,00418	kg Sb eq / kg
Raw	(unspecified)	Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore	0,00418	kg Sb eq / kg
Raw	(unspecified)	Nickel, 1.13% in sulfides, 0.76% in crude ore	0,00418	kg Sb eq / kg
Raw	(unspecified)	Nickel, 1.98% in silicates, 1.04% in crude ore	0,00418	kg Sb eq / kg
Raw	(unspecified)	Niobium	0,0655	kg Sb eq / kg
Raw	(unspecified)	Oil, crude	0,00000033	kg Sb eq / kg
Raw	(unspecified)	Palladium	9,36	kg Sb eq / kg
Raw	(unspecified)	Palladium, Pd 2.0E-4%, Pt 4.8E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore	9,36	kg Sb eq / kg
Raw	(unspecified)	Palladium, Pd 7.3E-4%, Pt 2.5E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore	9,36	kg Sb eq / kg
Raw	(unspecified)	Peat	5,67E-08	kg Sb eq / kg
Raw	(unspecified)	Perlite	0,0000388	kg Sb eq / kg
Raw	(unspecified)	Phosphorus	0,0000621	kg Sb eq / kg
Raw	(unspecified)	Phosphorus, 18% in apatite, 4% in crude ore	0,0000621	kg Sb eq / kg
Raw	(unspecified)	Platinum	9,09	kg Sb eq / kg
Raw	(unspecified)	Platinum, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore	9,09	kg Sb eq / kg
Raw	(unspecified)	Platinum, Pt 4.8E-4%, Pd 2.0E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore	9,09	kg Sb eq / kg
Raw	(unspecified)	Potassium	0,000009	kg Sb eq / kg
Raw	(unspecified)	Praseodymium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Rhenium	31,9	kg Sb eq / kg
Raw	(unspecified)	Scandium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Selenium	7,35	kg Sb eq / kg
Raw	(unspecified)	Silver	8,42	kg Sb eq / kg

Raw	(unspecified)	Silver, 0.007% in sulfide, Ag 0.004%, Pb, Zn, Cd, In	8,42	kg Sb eq / kg
Raw	(unspecified)	Silver, 3.2ppm in sulfide, Ag 1.2ppm, Cu and Te, in crude ore	8,42	kg Sb eq / kg
Raw	(unspecified)	Silver, Ag 2.1E-4%, Au 2.1E-4%, in ore	8,42	kg Sb eq / kg
Raw	(unspecified)	Silver, Ag 4.2E-3%, Au 1.1E-4%, in ore	8,42	kg Sb eq / kg
Raw	(unspecified)	Silver, Ag 4.6E-5%, Au 1.3E-4%, in ore	8,42	kg Sb eq / kg
Raw	(unspecified)	Silver, Ag 9.7E-4%, Au 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore	8,42	kg Sb eq / kg
Raw	(unspecified)	Sodium chloride	0,000000556	kg Sb eq / kg
Raw	(unspecified)	Sodium sulphate	0,00000992	kg Sb eq / kg
Raw	(unspecified)	Strontium	0,177	kg Sb eq / kg
Raw	(unspecified)	Sulfur	0,000391	kg Sb eq / kg
Raw	(unspecified)	Talc	0,00118	kg Sb eq / kg
Raw	(unspecified)	Tantalum	11,5	kg Sb eq / kg
Raw	(unspecified)	Tellurium	7,21	kg Sb eq / kg
Raw	(unspecified)	Terbium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Thallium	2980	kg Sb eq / kg
Raw	(unspecified)	Thulium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Tin	0,115	kg Sb eq / kg
Raw	(unspecified)	Titanium	0,00152	kg Sb eq / kg
Raw	(unspecified)	Tungsten	0,254	kg Sb eq / kg
Raw	(unspecified)	Uranium	0,195	kg Sb eq / kg
Raw	(unspecified)	Vanadium	0,00493	kg Sb eq / kg
Raw	(unspecified)	Vermiculite	0,00111	kg Sb eq / kg
Raw	(unspecified)	Ytterbium	0,000569	kg Sb eq / kg
Raw	(unspecified)	Yttrium	0,816	kg Sb eq / kg
Raw	(unspecified)	Zinc	0,00365	kg Sb eq / kg
Raw	(unspecified)	Zinc 9%, Lead 5%, in sulfide	0,00365	kg Sb eq / kg
Raw	(unspecified)	Zinc, Zn 0.63%, Au 9.7E-4%, Ag 9.7E-4%, Cu 0.38%, Pb 0.014%, in ore	0,00365	kg Sb eq / kg
Raw	(unspecified)	Zirconium	0,0164	kg Sb eq / kg

IMPACT 2002+ V2.11

IMPACT 2002+ is a combination of four methods: IMPACT 2002 (Pennington et al. 2005), Eco-indicator 99 (Goedkoop and Spriensma. 2000, 2nd version, Egalitarian Factors), CML (Guinée et al. 2002) and IPCC.

About weighting: The authors of IMPACT 2002+ suggest considering the four damage oriented impact categories human health, ecosystem quality, climate change, and resources separately for the interpretation phase of LCA (see the IMPACT 2002+ user guidelines on http://www.impactmodeling.org).
The authors also suggest that if aggregation is needed, one could use self-determined weighting factors or a default weighting factor of one. As a default SimaPro also offers this weighting of 1:1:1:1
They also strongly recommend using the weighting triangle which helps analyzing the different weightings, rather than taking a decision instead of the decision maker. As the weighting triangle can only assess 3 damage categories at one time, Annex 5 of the IMPACT 2002+ user guidelines explains how to combine the climate change and resources consumption damage categories in order to have just 3 indicators.

Contact info: http://www.impactmodeling.org

The IMPACT 2002+ method was largely based on Eco-indicator 99. Compared to eco-indicator 99 the following changes were implemented:

- IMPACT 2002 factors replace Eco-indicator's Human Health carcinogenic and non-carcinogenic factors and for Aquatic and Terrestrial ecotoxicity factors.
- CML factors were used for Aquatic acidification and Aquatic eutrophication. The Aquatic eutrophication CF implemented in this method are those for a P-limited watershed.
- Climate change was redefined and separated from Human Health impacts and added as a separate damage category. The characterisation factors of IPPC 2001 500a were used for this impact category.
- For fossil fuel depletion the Energy content was used instead of the surplus energy needed for extraction. In the Resource depletion category however, results for mineral extraction and fossil fuel depletion were added together even though fossil energy content and surplus energy for minerals represent different concepts.
- The Eco-indicator 99 factors for Respiratory effects, Ionizing radiations, Land use and Mineral extraction remained unchanged.

The respective midpoint units are the following:
- kg chloroethylene equivalents into air (written “kg C2H3Cl eq”) for Carcinogens and Non-carcinogens,
- kg PM2.5 equivalents into air (written “kg PM2.5 eq”) for Respiratory inorganics,
- Bq C-14 equivalents into air (written “Bq C-14 eq”) for Ionizing radiation,
- kg CFC-11 equivalents into air (written “kg CFC-11 eq”) for Ozone layer depletion,
- kg ethylene equivalents into air (written “kg C2H4 eq”) for Respiratory organics,
- kg triethylene glycol equivalents into water (written “kg TEG water”) for Aquatic ecotoxicity,
- kg triethylene glycol equivalents into soil (written “kg TEG soil”) for Terrestrial ecotoxicity,
- kg SO2 equivalents into air (written “kg SO2 eq”) for Terrestrial acidi/nutri,
- m2 organic arable land (written “m2org.arable”) for Land occupation,
- kg SO2 equivalents into air (written “kg SO2 eq”) for Aquatic acidification,

- kg PO4--- equivalents into a P-limited water (written “kg PO4 P-lim”) for Aquatic eutrophication,
- kgCO2 equivalents into air (written “kg CO2 eq”) for Global warming,
- MJ primary non-renewable (written “MJ primary”) for Non-renewable energy and
- MJ surplus (written “MJ surplus”) for Mineral extraction. A

The respective damage units are DALY for Human health, PDF*m2*yr for Ecosystem quality, kgeq CO2 into air (written “kg CO2 eq”) for Climate change and MJ primary non-renewable (written “MJ primary”) for Resources. These characterization factors are from the file "IMPACT2002+_v2.1_CF_1a.xls".

The supporting documents for IMPACT 2002+ (Jolliet et al. 2003, Humbert et al. 2009) and the factors can be downloaded at www.impactmodeling.org. This version has been formatted and released in October 2005. By Sébastien Humbert, info@impactmodeling.org, EPFL, October 2005. This file takes into account the updates regarding the flows Molybdenum (should be non-cancer), Chlordane (and its isomers), Cyhalothrin (and lambda- and gamma-) and Phthalate ("Phthalate, dioctyl-" has been changed by "Phthalate, di(2-ethylhexyl)-"). Characterization factors for "groundwater", "groundwater, long-term" and "ocean" emissions for carcinogens, non-carcinogens, aquatic ecotoxicity and terrestrial ecotoxicity have been set to 0. However, this does not indicate that no impacts will occur, but that currently we do not have available CF for groundwater emissions. See also: Humbert S, Margni M and Jolliet O (2009), IMPACT 2002+ : User Guide, Draft for version 2.1.

Impact categories Aquatic acidification and Aquatic eutrophication are midpoint indicators only, and therefore are not included in the endpoint.

Normalization:
The damage factor reported in ecoinvent are normalized by dividing the impact per unit of emission by the total impact of all substances of the specific category for which characterization factors exist, per person per year (for Europe).

Weighting:
Use default weighting factor of one, unless other social weighting values are available.

Ref: Jolliet O, Margni M, Charles R, Humbert S, Payet J, Rebitzer G and Rosenbaum R (2003). “IMPACT 2002+: A New Life Cycle Impact Assessment Methodology.” Int J LCA 8 (6) 324-330.

For further information see the database manual.

Update version 2.01:
IMPACT 2002+ version 2.01 (October 2005) is the same as version 2.00 (March 2004) with the DALY per case of cancer and non-cancer updated from 6.7 and 0.67 to 13 and 1.3 respectively (in accordance with Keller (2005)).

Update version 2.02:
Version 2.02 replaces version 2.01 which contained an error in the damage assessment.

Update version 2.03:
Substances under non material emissions are appended with corresponding substances in raw, air and water compartments.

Other adaptations (February 2008, v2.04):

- Minor adaptations in Unit names and Impact category names (capitals, points) for more consistency with other categories.

Other adaptation (April 2008, v2.05):
- The impact category 'Global warming' is adapted.The substance 'carbon dioxide, land transformation' is added, with the same characterisation factor of 'carbon dioxide'.

Other adaptation (April 2009, v2.06)":
- Changed characterisation factor of 'methane, biogenic' in the impact category 'Global warming' from 0 to 4.25 (personal communication with Sebastien Humbert, Quantis, info@impactmodeling.org) :
CH4, biogenic is given a CF of 4.85, which reflects the GWP of the CH4 before it becomes CO2 (the later having a GWP of 0). 1 kg of CH4 results in 2.75 kg of CO2, meaning that in the value of 7.6 kgCO2eq/kgCH4, actually 2.75 kgCO2eq/kgCH4 come from the CO2 that will be formed once the CH4 degrade, and only 4.85 kgCO2eq/kgCH4 comes from the CH4 itself before it degrades into CO2).
- Carbon dioxide biogenic Carbon monoxide Biogenic and carbon uptake were taken out (they were previously already set to zero). This is in line with the other methods in SimaPro.

Other adaptation (September 2010, v2.1):
- Changed characterisation factor in the impact category 'Global warming' of:
    - 'methane' to 7.6 (personal communication with Sebastien Humbert, Quantis, info@impactmodeling.org)
    - 'methane, biogenic' to 7.6 (personal communication with Sebastien Humbert, Quantis, info@impactmodeling.org)
    - 'methane, fossil' to 10.35 (personal communication with Sebastien Humbert, Quantis, info@impactmodeling.org)

Other adaptation (October 2013, v2.11):
- Deleted Methane, tetrafluoro- from Aquatic ecotoxicity due to inconsistency with Methane, tetrafluoro-, CFC-14 (deleted factor is lowest)
- Deleted Methane, tetrafluoro-, CFC-14 from Aquatic ecotoxicity due to inconsistency with Methane, tetrafluoro- (deleted factor is lowest)
- Added CFs for missing land occupation types
- Added some missing mineral resource flow synonyms.

Impact category	Respiratory inorganics	kg PM2.5 eq		
Air	(unspecified)	Ammonia	0,121428571	kg PM2.5 eq / kg
Air	(unspecified)	Carbon monoxide	0,001044286	kg PM2.5 eq / kg
Air	(unspecified)	Nitric oxide	0,195714286	kg PM2.5 eq / kg
Air	(unspecified)	Nitrogen dioxide	0,127285714	kg PM2.5 eq / kg
Air	(unspecified)	Nitrogen oxides	0,127285714	kg PM2.5 eq / kg
Air	(unspecified)	Particulates	0,157142857	kg PM2.5 eq / kg
Air	(unspecified)	Particulates, < 10 um	0,535714286	kg PM2.5 eq / kg
Air	(unspecified)	Particulates, < 10 um (mobile)	0,535714286	kg PM2.5 eq / kg
Air	(unspecified)	Particulates, < 10 um (stationary)	0,535714286	kg PM2.5 eq / kg
Air	(unspecified)	Particulates, < 2.5 um	1	kg PM2.5 eq / kg
Air	(unspecified)	Sulfur dioxide	0,078	kg PM2.5 eq / kg
Air	(unspecified)	Sulfur monoxide	0,078	kg PM2.5 eq / kg
Air	(unspecified)	Sulfur trioxide	0,062428571	kg PM2.5 eq / kg
Air	(unspecified)	TSP	0,157142857	kg PM2.5 eq / kg

Impact category	Respiratory organics	kg C2H4 eq		
Air	(unspecified)	1-Butanol	1,276995305	kg C2H4 eq / kg
Air	(unspecified)	1-Butene	1,079812207	kg C2H4 eq / kg
Air	(unspecified)	1-Butene, 2-methyl-	0,798122066	kg C2H4 eq / kg
Air	(unspecified)	1-Butene, 3-methyl-	0,680751174	kg C2H4 eq / kg
Air	(unspecified)	1-Hexene	0,877934272	kg C2H4 eq / kg
Air	(unspecified)	1-Pentene	1	kg C2H4 eq / kg
Air	(unspecified)	1-Propanol	0,558685446	kg C2H4 eq / kg
Air	(unspecified)	2-Butanol	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	2-Butanone, 3-methyl-	0,367605634	kg C2H4 eq / kg
Air	(unspecified)	2-Butene (cis)	1,159624413	kg C2H4 eq / kg
Air	(unspecified)	2-Butene (trans)	1,159624413	kg C2H4 eq / kg
Air	(unspecified)	2-Butene, 2-methyl-	0,840375587	kg C2H4 eq / kg
Air	(unspecified)	2-Hexanone	0,558685446	kg C2H4 eq / kg
Air	(unspecified)	2-Hexene (cis)	1,079812207	kg C2H4 eq / kg
Air	(unspecified)	2-Hexene (trans)	1,079812207	kg C2H4 eq / kg
Air	(unspecified)	2-Methyl-1-propanol	0,379812207	kg C2H4 eq / kg
Air	(unspecified)	2-Methyl-2-butanol	0,143661972	kg C2H4 eq / kg
Air	(unspecified)	2-Pentanone	0,558685446	kg C2H4 eq / kg
Air	(unspecified)	2-Pentene (cis)	1,117370892	kg C2H4 eq / kg
Air	(unspecified)	2-Pentene (trans)	1,117370892	kg C2H4 eq / kg
Air	(unspecified)	2-Propanol	0,139906103	kg C2H4 eq / kg
Air	(unspecified)	3-Hexanone	0,600938967	kg C2H4 eq / kg
Air	(unspecified)	3-Methyl-1-butanol	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	3-Pentanol	0,43943662	kg C2H4 eq / kg
Air	(unspecified)	3-Pentanone	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	3,3-Dimethyl-2-butanone	0,327699531	kg C2H4 eq / kg
Air	(unspecified)	4-Hydroxy-4-methyl-2-pentanone	0,263849765	kg C2H4 eq / kg
Air	(unspecified)	4-Methyl-2-pentanone	0,478873239	kg C2H4 eq / kg
Air	(unspecified)	Acetaldehyde	0,638497653	kg C2H4 eq / kg
Air	(unspecified)	Acetic acid	0,1	kg C2H4 eq / kg
Air	(unspecified)	Acetone	0,095774648	kg C2H4 eq / kg
Air	(unspecified)	Alcohols, unspecified	0,356807512	kg C2H4 eq / kg
Air	(unspecified)	Aldehydes, unspecified	0,657276995	kg C2H4 eq / kg
Air	(unspecified)	Benzene	0,21971831	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 1,2,3-trimethyl-	1,276995305	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 1,2,4-trimethyl-	1,276995305	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 1,3,5-trimethyl-	1,399061033	kg C2H4 eq / kg
Air	(unspecified)	Benzene, 3,5-dimethylethyl-	1,319248826	kg C2H4 eq / kg
Air	(unspecified)	Benzene, ethyl-	0,718309859	kg C2H4 eq / kg
Air	(unspecified)	Butadiene	0,877934272	kg C2H4 eq / kg
Air	(unspecified)	Butanal	0,798122066	kg C2H4 eq / kg
Air	(unspecified)	Butane	0,355399061	kg C2H4 eq / kg
Air	(unspecified)	Butane, 2,2-dimethyl-	0,243661972	kg C2H4 eq / kg
Air	(unspecified)	Butane, 2,3-dimethyl-	0,558685446	kg C2H4 eq / kg
Air	(unspecified)	Butanol, 2-methyl-1-	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	Butanol, 3-methyl-2-	0,371361502	kg C2H4 eq / kg
Air	(unspecified)	Butene	1,159624413	kg C2H4 eq / kg
Air	(unspecified)	Butyl acetate	0,243661972	kg C2H4 eq / kg
Air	(unspecified)	Chloroform	0,023192488	kg C2H4 eq / kg
Air	(unspecified)	Cumene	0,521126761	kg C2H4 eq / kg
Air	(unspecified)	Cyclohexane	0,291549296	kg C2H4 eq / kg
Air	(unspecified)	Cyclohexanol	0,43943662	kg C2H4 eq / kg
Air	(unspecified)	Cyclohexanone	0,303755869	kg C2H4 eq / kg
Air	(unspecified)	Decane	0,387793427	kg C2H4 eq / kg
Air	(unspecified)	Dichlorprop	0,151643192	kg C2H4 eq / kg
Air	(unspecified)	Diethyl ether	0,478873239	kg C2H4 eq / kg
Air	(unspecified)	Diisopropyl ether	0,478873239	kg C2H4 eq / kg
Air	(unspecified)	Dimethyl ether	0,175586854	kg C2H4 eq / kg
Air	(unspecified)	Dodecane	0,359624413	kg C2H4 eq / kg
Air	(unspecified)	Esters, unspecified	0,17370892	kg C2H4 eq / kg
Air	(unspecified)	Ethane	0,123943662	kg C2H4 eq / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	0,009201878	kg C2H4 eq / kg
Air	(unspecified)	Ethanol	0,391549296	kg C2H4 eq / kg
Air	(unspecified)	Ethanol, 2-butoxy-	0,43943662	kg C2H4 eq / kg
Air	(unspecified)	Ethanol, 2-ethoxy-	0,391549296	kg C2H4 eq / kg
Air	(unspecified)	Ethanol, 2-methoxy-	0,303755869	kg C2H4 eq / kg
Air	(unspecified)	Ethene	1	kg C2H4 eq / kg
Air	(unspecified)	Ethene, dichloro- (cis)	0,43943662	kg C2H4 eq / kg
Air	(unspecified)	Ethene, dichloro- (trans)	0,395774648	kg C2H4 eq / kg

Air	(unspecified)	Ethene, tetrachloro-	0,02915493	kg C2H4 eq / kg
Air	(unspecified)	Ethene, trichloro-	0,327699531	kg C2H4 eq / kg
Air	(unspecified)	Ethers, unspecified	0,34741784	kg C2H4 eq / kg
Air	(unspecified)	Ethyl acetate	0,215962441	kg C2H4 eq / kg
Air	(unspecified)	Ethylene glycol	0,387793427	kg C2H4 eq / kg
Air	(unspecified)	Ethyne	0,087793427	kg C2H4 eq / kg
Air	(unspecified)	Formaldehyde	0,521126761	kg C2H4 eq / kg
Air	(unspecified)	Formic acid	0,032347418	kg C2H4 eq / kg
Air	(unspecified)	Heptane	0,521126761	kg C2H4 eq / kg
Air	(unspecified)	Hexane	0,478873239	kg C2H4 eq / kg
Air	(unspecified)	Hexane, 2-methyl-	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	Hexane, 3-methyl-	0,367605634	kg C2H4 eq / kg
Air	(unspecified)	Hydrocarbons, aliphatic, alkanes, unspecified	0,352112676	kg C2H4 eq / kg
Air	(unspecified)	Hydrocarbons, aliphatic, alkenes, unspecified	0,985915493	kg C2H4 eq / kg
Air	(unspecified)	Hydrocarbons, aromatic	0,985915493	kg C2H4 eq / kg
Air	(unspecified)	Hydrocarbons, chlorinated	0,164319249	kg C2H4 eq / kg
Air	(unspecified)	Hydrocarbons, halogenated	0,164319249	kg C2H4 eq / kg
Air	(unspecified)	Isobutane	0,311737089	kg C2H4 eq / kg
Air	(unspecified)	Isobutene	0,638497653	kg C2H4 eq / kg
Air	(unspecified)	Isobutyraldehyde	0,521126761	kg C2H4 eq / kg
Air	(unspecified)	Isopentane	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	Isoprene	1,117370892	kg C2H4 eq / kg
Air	(unspecified)	Isopropyl acetate	0,215962441	kg C2H4 eq / kg
Air	(unspecified)	Ketones, unspecified	0,408450704	kg C2H4 eq / kg
Air	(unspecified)	m-Xylene	1,117370892	kg C2H4 eq / kg
Air	(unspecified)	Methane	0,00600939	kg C2H4 eq / kg
Air	(unspecified)	Methane, dichloro-, HCC-30	0,068075117	kg C2H4 eq / kg
Air	(unspecified)	Methane, monochloro-, R-40	0,005211268	kg C2H4 eq / kg
Air	(unspecified)	Methanol	0,131924883	kg C2H4 eq / kg
Air	(unspecified)	Methyl acetate	0,047887324	kg C2H4 eq / kg
Air	(unspecified)	Methyl ethyl ketone	0,379812207	kg C2H4 eq / kg
Air	(unspecified)	Methyl formate	0,033568075	kg C2H4 eq / kg
Air	(unspecified)	N-octane	0,43943662	kg C2H4 eq / kg
Air	(unspecified)	N-propylbenzene	0,638497653	kg C2H4 eq / kg
Air	(unspecified)	NMVOC, non-methane volatile organic compounds, unspecified origin	0,600938967	kg C2H4 eq / kg
Air	(unspecified)	Nonane	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	o-Xylene	1,079812207	kg C2H4 eq / kg
Air	(unspecified)	p-Xylene	1,037558685	kg C2H4 eq / kg
Air	(unspecified)	PAH, polycyclic aromatic hydrocarbons	0,985915493	kg C2H4 eq / kg
Air	(unspecified)	Pentanal	0,76056338	kg C2H4 eq / kg
Air	(unspecified)	Pentane	0,399530516	kg C2H4 eq / kg
Air	(unspecified)	Pentane, 2-methyl-	0,43943662	kg C2H4 eq / kg
Air	(unspecified)	Pentane, 3-methyl-	0,478873239	kg C2H4 eq / kg
Air	(unspecified)	Propanal	0,798122066	kg C2H4 eq / kg
Air	(unspecified)	Propane	0,179812207	kg C2H4 eq / kg
Air	(unspecified)	Propane, 2,2-dimethyl-	0,175586854	kg C2H4 eq / kg
Air	(unspecified)	Propanol, 1-butoxy-2-	0,43943662	kg C2H4 eq / kg
Air	(unspecified)	Propene	1,117370892	kg C2H4 eq / kg
Air	(unspecified)	Propyl acetate	0,291549296	kg C2H4 eq / kg
Air	(unspecified)	Propylene glycol	0,478873239	kg C2H4 eq / kg
Air	(unspecified)	Propylene glycol methyl ether	0,371361502	kg C2H4 eq / kg
Air	(unspecified)	s-Butyl acetate	0,271830986	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl acetate	0,063849765	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl alcohol	0,123943662	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl ethyl ether	0,215962441	kg C2H4 eq / kg
Air	(unspecified)	t-Butyl methyl ether	0,155868545	kg C2H4 eq / kg
Air	(unspecified)	Toluene	0,638497653	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 2-ethyl-	0,920187793	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 3-ethyl-	1,037558685	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 3,5-diethyl-	1,319248826	kg C2H4 eq / kg
Air	(unspecified)	Toluene, 4-ethyl-	0,920187793	kg C2H4 eq / kg
Air	(unspecified)	Undecane	0,387793427	kg C2H4 eq / kg
Air	(unspecified)	VOC, volatile organic compounds	0,303286385	kg C2H4 eq / kg
Air	(unspecified)	VOC, volatile organic compounds as C	0,60657277	kg C2H4 eq / kg
Air	(unspecified)	Xylene	1,037558685	kg C2H4 eq / kg

ReCiPe Midpoint (H) V1.08

ReCiPe midpoint method, hierarchist version. The default ReCiPe midpoint method is the Hierarchist version, with European normalisation.

The ReCiPe method was created by RIVM, CML, PRé Consultants, Radboud Universiteit Nijmegen and CE Delft. In ReCiPe you can choose to use midpoint indicators or endpoint indicators. Each method has been created for three different perspectives. More information on the method via www.lcia-ReCiPe.net.

Evaluation:
"Europe ReCiPe H" refers to the normalisation values of Europe.
"World ReCiPe H" refers to the normalisation values of the world.

In case the original method only reported a characterisation value for one specific subcompartment, this value is taken as the characterisation value for all subcompartments in this compartment.
The characterisation values of the subcompartments "fresh water", "high population density" and "industrial soil" were used for the subcompartment "unspecified".

Adaptations (Version 1.01, 2008)
- Removed subcompartments of resources. Added PM<10 substance with the same characterisation value of 2.5>PM<10. Added Sulfur oxides with the same characterisation value of sulfur dioxide.

Other adaptations (Version 1.02, October 2009)
- Toxicity figures have been updated both midpoint as endpoint.
- Changed characterization value of 'Methane, biogenic' in Climate change from 25 to 22.

Other adaptations (Version 1.03, November 2009)
- Some substance names were changed to be consistent with the original nomenclature in SimaPro.
- NO2 added in impact categories Photochemical oxidant formation, Particulate matter formation, Terrestrial acidification, with the same factor as NOx
- Substances were added to impact category Freshwater eutrophication.
- Substances were added to impact category Marine eutrophication. Substances cyanide and nitrite to air and water were removed. Substances to air, Manure N and Fertiliser N were removed due to double counting. Characterisation factors for ammonia and nitrate to water were corrected.

Other adaptations (Version 1.04, March 2010)
- Added normalisation figures for Freshwater eutrophication and Marine eutrophication again to correct their exclusion in ReCiPe version 1.03.
- In impact category Terrestrial acidification the characterisation value of NO2 was changed to 0.56.

Other adaptations (Version 1.05, July 2010)
- Recalculated normalisation factors in order to: correct the European and Global values of benzene and dioxins. exclude the double value for 'Coal, hard, unspecified, in ground' in the European situation.

Other adaptations (Version 1.06, July 2011)
- Waterborne emissions of copper were added to all toxicity impact categories.

- Missing CF of airborne emission "Ethane, 1,1,1-trichloro-, HCFC-140" was added.
- The following emissions were added/updated in the impact category "Marine eutrophication":

    CF of airborne emission "Nitrogen dioxide" = 0.039 kg N-eq/kg
    CF of airborne emission "Nitrogen oxides" = 0.39 kg N-eq/kg
    CF of airborne emission "Nitric oxide" = 0.060 kg N-eq/kg
    CF of waterborne emission "Cyanide" = 0.54 kg N-eq/kg
    CF of waterborne emission "Nitrite" = 0.30 kg N-eq/kg

- Normalization factors for all toxicity impact categories and marine eutrophication were update as response to the adaptations above mentioned.
- Recalculated normalisation factors in order to correct the European and Global values of metal emissions which were implemented as "metal, ion" instead of "metal" and the changes mentioned above.

Other adaptations (Version 1.07, June 2012)
- Characterization factor of 'Methane, biogenic' in 'Climate change' impact category corrected for rounding error
- Added 'Tributyltin oxide', 'Triethyl amine', and 'Vinyl acetate' emissions to water to exotoxicity and human toxicity impact categories.
- Added 'Phosphorus' emissions to soil to 'Human toxicity' impact category.
- Adapted characterization factors of Fossil depletion, consistently using the lower heating values.

Other adaptations (Version 1.08, October 2013)
- Several characterisation factors added to the impact categories Human toxicity, Freshwater ecotoxicity, and Terrestrial ecotoxicity.
- Characterisation factors added to the impact category Marine eutrophication (all N emissions to ocean).
- Phosphorus deleted from toxicity impact categories, because it referred to white phosphorus.

Impact category	Ozone depletion	kg CFC-11 eq		
Air	(unspecified)	Ethane, 1-chloro-1,1-difluoro-, HCFC-142b	0,07	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	0,12	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	0,12	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1,1,2-tetrafluoro-2-bromo-, Halon 2401	0,25	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1,2-trichloro-	0,12	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	1	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,2-dibromotetrafluoro-, Halon 2402	6	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	0,94	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	0,02	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	0,02	kg CFC-11 eq / kg
Air	(unspecified)	Ethane, chloropentafluoro-, CFC-115	0,44	kg CFC-11 eq / kg
Air	(unspecified)	Halothane	0,14	kg CFC-11 eq / kg
Air	(unspecified)	Hydrocarbons, chlorinated	0,00617	kg CFC-11 eq / kg
Air	(unspecified)	Methane, bromo-, Halon 1001	0,38	kg CFC-11 eq / kg
Air	(unspecified)	Methane, bromochlorodifluoro-, Halon 1211	6	kg CFC-11 eq / kg
Air	(unspecified)	Methane, bromodifluoro-, Halon 1201	1,4	kg CFC-11 eq / kg
Air	(unspecified)	Methane, bromotrifluoro-, Halon 1301	12	kg CFC-11 eq / kg
Air	(unspecified)	Methane, chlorodifluoro-, HCFC-22	0,05	kg CFC-11 eq / kg
Air	(unspecified)	Methane, dibromodifluoro-, Halon 1202	1,3	kg CFC-11 eq / kg
Air	(unspecified)	Methane, dichlorodifluoro-, CFC-12	1	kg CFC-11 eq / kg
Air	(unspecified)	Methane, monochloro-, R-40	0,02	kg CFC-11 eq / kg
Air	(unspecified)	Methane, tetrachloro-, CFC-10	0,73	kg CFC-11 eq / kg
Air	(unspecified)	Methane, trichlorofluoro-, CFC-11	1	kg CFC-11 eq / kg
Air	(unspecified)	Propane, 1,3-dichloro-1,1,2,2,3-pentafluoro-, HCFC-225cb	0,03	kg CFC-11 eq / kg
Air	(unspecified)	Propane, 3,3-dichloro-1,1,1,2,2-pentafluoro-, HCFC-225ca	0,02	kg CFC-11 eq / kg

Impact category	Photochemical oxidant formation	kg NMVOC		
Air	(unspecified)	1-Butanol	1,05	kg NMVOC / kg
Air	(unspecified)	1-Butene	1,82	kg NMVOC / kg
Air	(unspecified)	1-Butene, 2-methyl-	1,3	kg NMVOC / kg
Air	(unspecified)	1-Butene, 3-methyl-	1,13	kg NMVOC / kg
Air	(unspecified)	1-Hexene	1,48	kg NMVOC / kg
Air	(unspecified)	1-Pentene	1,65	kg NMVOC / kg
Air	(unspecified)	1-Propanol	0,948	kg NMVOC / kg
Air	(unspecified)	2-Butanol	0,676	kg NMVOC / kg
Air	(unspecified)	2-Butanone, 3-methyl-	0,615	kg NMVOC / kg
Air	(unspecified)	2-Butene (cis)	1,94	kg NMVOC / kg
Air	(unspecified)	2-Butene (trans)	1,91	kg NMVOC / kg
Air	(unspecified)	2-Butene, 2-methyl-	1,42	kg NMVOC / kg
Air	(unspecified)	2-Hexanone	0,966	kg NMVOC / kg
Air	(unspecified)	2-Hexene (cis)	1,81	kg NMVOC / kg
Air	(unspecified)	2-Hexene (trans)	1,81	kg NMVOC / kg
Air	(unspecified)	2-Methyl-1-propanol	0,608	kg NMVOC / kg
Air	(unspecified)	2-Methyl-2-butanol	0,385	kg NMVOC / kg
Air	(unspecified)	2-Pentanone	0,926	kg NMVOC / kg
Air	(unspecified)	2-Pentene (cis)	1,89	kg NMVOC / kg
Air	(unspecified)	2-Pentene (trans)	1,89	kg NMVOC / kg
Air	(unspecified)	2-Propanol	0,318	kg NMVOC / kg
Air	(unspecified)	3-Hexanone	1,01	kg NMVOC / kg
Air	(unspecified)	3-Methyl-1-butanol	0,731	kg NMVOC / kg
Air	(unspecified)	3-Pentanol	1,01	kg NMVOC / kg
Air	(unspecified)	3-Pentanone	0,699	kg NMVOC / kg
Air	(unspecified)	3,3-Dimethyl-2-butanone	0,546	kg NMVOC / kg
Air	(unspecified)	4-Hydroxy-4-methyl-2-pentanone	0,519	kg NMVOC / kg
Air	(unspecified)	4-Methyl-2-pentanone	0,828	kg NMVOC / kg
Air	(unspecified)	Acetaldehyde	1,08	kg NMVOC / kg
Air	(unspecified)	Acetic acid	0,164	kg NMVOC / kg
Air	(unspecified)	Acetone	0,159	kg NMVOC / kg
Air	(unspecified)	Aldehydes, unspecified	0,927	kg NMVOC / kg
Air	(unspecified)	Benzaldehyde	-0,155	kg NMVOC / kg
Air	(unspecified)	Benzene	0,368	kg NMVOC / kg
Air	(unspecified)	Benzene, 1,2,3-trimethyl-	2,14	kg NMVOC / kg
Air	(unspecified)	Benzene, 1,2,4-trimethyl-	2,16	kg NMVOC / kg
Air	(unspecified)	Benzene, 1,3,5-trimethyl-	2,33	kg NMVOC / kg
Air	(unspecified)	Benzene, 3,5-dimethylethyl-	2,23	kg NMVOC / kg
Air	(unspecified)	Benzene, ethyl-	1,23	kg NMVOC / kg
Air	(unspecified)	Butadiene	1,44	kg NMVOC / kg
Air	(unspecified)	Butanal	1,34	kg NMVOC / kg
Air	(unspecified)	Butane	0,595	kg NMVOC / kg
Air	(unspecified)	Butane, 2,2-dimethyl-	0,407	kg NMVOC / kg
Air	(unspecified)	Butane, 2,3-dimethyl-	0,914	kg NMVOC / kg
Air	(unspecified)	Butanol, 2-methyl-1-	0,826	kg NMVOC / kg
Air	(unspecified)	Butanol, 3-methyl-2-	0,686	kg NMVOC / kg
Air	(unspecified)	Butyl acetate	0,454	kg NMVOC / kg
Air	(unspecified)	Carbon monoxide	0,0456	kg NMVOC / kg
Air	(unspecified)	Carbon monoxide, biogenic	0,0456	kg NMVOC / kg
Air	(unspecified)	Carbon monoxide, fossil	0,0456	kg NMVOC / kg
Air	(unspecified)	Chloroform	0,0389	kg NMVOC / kg
Air	(unspecified)	Cumene	0,845	kg NMVOC / kg
Air	(unspecified)	Cyclohexane	0,49	kg NMVOC / kg
Air	(unspecified)	Cyclohexanol	0,875	kg NMVOC / kg
Air	(unspecified)	Cyclohexanone	0,505	kg NMVOC / kg
Air	(unspecified)	Decane	0,649	kg NMVOC / kg
Air	(unspecified)	Diethyl ether	0,752	kg NMVOC / kg
Air	(unspecified)	Diisopropyl ether	0,672	kg NMVOC / kg
Air	(unspecified)	Dimethyl carbonate	0,0422	kg NMVOC / kg
Air	(unspecified)	Dimethyl ether	0,319	kg NMVOC / kg
Air	(unspecified)	Dodecane	0,603	kg NMVOC / kg
Air	(unspecified)	Ethane	0,208	kg NMVOC / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	0,0152	kg NMVOC / kg
Air	(unspecified)	Ethanol	0,674	kg NMVOC / kg
Air	(unspecified)	Ethanol, 2-butoxy-	0,816	kg NMVOC / kg

Air	(unspecified)	Ethanol, 2-ethoxy-	0,652	kg NMVOC / kg
Air	(unspecified)	Ethanol, 2-methoxy-	0,519	kg NMVOC / kg
Air	(unspecified)	Ethene	1,69	kg NMVOC / kg
Air	(unspecified)	Ethene, dichloro- (cis)	0,755	kg NMVOC / kg
Air	(unspecified)	Ethene, dichloro- (trans)	0,662	kg NMVOC / kg
Air	(unspecified)	Ethene, tetrachloro-	0,049	kg NMVOC / kg
Air	(unspecified)	Ethene, trichloro-	0,549	kg NMVOC / kg
Air	(unspecified)	Ethyl acetate	0,353	kg NMVOC / kg
Air	(unspecified)	Ethylene glycol	0,63	kg NMVOC / kg
Air	(unspecified)	Ethyne	0,144	kg NMVOC / kg
Air	(unspecified)	Formaldehyde	0,877	kg NMVOC / kg
Air	(unspecified)	Formic acid	0,0541	kg NMVOC / kg
Air	(unspecified)	Heptane	0,834	kg NMVOC / kg
Air	(unspecified)	Hexane	0,814	kg NMVOC / kg
Air	(unspecified)	Hexane, 2-methyl-	0,694	kg NMVOC / kg
Air	(unspecified)	Hexane, 3-methyl-	0,615	kg NMVOC / kg
Air	(unspecified)	Hydrocarbons, aliphatic, alkanes, cyclic	0,476	kg NMVOC / kg
Air	(unspecified)	Hydrocarbons, aromatic	0,397	kg NMVOC / kg
Air	(unspecified)	Hydrocarbons, chlorinated	0,125	kg NMVOC / kg
Air	(unspecified)	Isobutane	0,519	kg NMVOC / kg
Air	(unspecified)	Isobutene	1,06	kg NMVOC / kg
Air	(unspecified)	Isobutyraldehyde	0,868	kg NMVOC / kg
Air	(unspecified)	Isopentane	0,684	kg NMVOC / kg
Air	(unspecified)	Isoprene	1,84	kg NMVOC / kg
Air	(unspecified)	Isopropyl acetate	0,356	kg NMVOC / kg
Air	(unspecified)	m-Xylene	1,87	kg NMVOC / kg
Air	(unspecified)	Methane	0,0101	kg NMVOC / kg
Air	(unspecified)	Methane, biogenic	0,0101	kg NMVOC / kg
Air	(unspecified)	Methane, dichloro-, HCC-30	0,115	kg NMVOC / kg
Air	(unspecified)	Methane, dimethoxy-	0,277	kg NMVOC / kg
Air	(unspecified)	Methane, fossil	0,0101	kg NMVOC / kg
Air	(unspecified)	Methane, monochloro-, R-40	0,00845	kg NMVOC / kg
Air	(unspecified)	Methanol	0,236	kg NMVOC / kg
Air	(unspecified)	Methyl acetate	0,0997	kg NMVOC / kg
Air	(unspecified)	Methyl ethyl ketone	0,63	kg NMVOC / kg
Air	(unspecified)	Methyl formate	0,0456	kg NMVOC / kg
Air	(unspecified)	N-octane	0,765	kg NMVOC / kg
Air	(unspecified)	N-propylbenzene	1,07	kg NMVOC / kg
Air	(unspecified)	Nitrogen dioxide	1	kg NMVOC / kg
Air	(unspecified)	Nitrogen oxides	1	kg NMVOC / kg
Air	(unspecified)	NMVOC, non-methane volatile organic compounds, unspecified origin	1	kg NMVOC / kg
Air	(unspecified)	Nonane	0,699	kg NMVOC / kg
Air	(unspecified)	o-Xylene	1,78	kg NMVOC / kg
Air	(unspecified)	p-Xylene	1,71	kg NMVOC / kg
Air	(unspecified)	Pentanal	1,29	kg NMVOC / kg
Air	(unspecified)	Pentane	0,667	kg NMVOC / kg
Air	(unspecified)	Pentane, 2-methyl-	0,709	kg NMVOC / kg
Air	(unspecified)	Pentane, 3-methyl-	0,809	kg NMVOC / kg
Air	(unspecified)	Propanal	1,35	kg NMVOC / kg
Air	(unspecified)	Propane	0,297	kg NMVOC / kg
Air	(unspecified)	Propane, 2,2-dimethyl-	0,292	kg NMVOC / kg
Air	(unspecified)	Propene	1,9	kg NMVOC / kg
Air	(unspecified)	Propionic acid	0,253	kg NMVOC / kg
Air	(unspecified)	Propyl acetate	0,476	kg NMVOC / kg
Air	(unspecified)	Propylene glycol	0,772	kg NMVOC / kg
Air	(unspecified)	Propylene glycol methyl ether	0,6	kg NMVOC / kg
Air	(unspecified)	Propylene glycol t-butyl ether	0,782	kg NMVOC / kg
Air	(unspecified)	s-Butyl acetate	0,465	kg NMVOC / kg
Air	(unspecified)	Styrene	0,24	kg NMVOC / kg
Air	(unspecified)	Sulfur dioxide	0,0811	kg NMVOC / kg
Air	(unspecified)	Sulfur monoxide	0,0811	kg NMVOC / kg
Air	(unspecified)	Sulfur oxides	0,0811	kg NMVOC / kg
Air	(unspecified)	t-Butyl acetate	0,0895	kg NMVOC / kg
Air	(unspecified)	t-Butyl alcohol	0,179	kg NMVOC / kg
Air	(unspecified)	t-Butyl ethyl ether	0,412	kg NMVOC / kg
Air	(unspecified)	t-Butyl methyl ether	0,296	kg NMVOC / kg
Air	(unspecified)	Toluene	1,08	kg NMVOC / kg
Air	(unspecified)	Toluene, 2-ethyl-	1,52	kg NMVOC / kg
Air	(unspecified)	Toluene, 3-ethyl-	1,72	kg NMVOC / kg
Air	(unspecified)	Toluene, 3,5-diethyl-	2,19	kg NMVOC / kg
Air	(unspecified)	Toluene, 4-ethyl-	1,53	kg NMVOC / kg
Air	(unspecified)	Undecane	0,649	kg NMVOC / kg

Impact category	Particulate matter formation	kg PM10 eq		
Air	(unspecified)	Ammonia	0,32	kg PM10 eq / kg
Air	(unspecified)	Nitrogen dioxide	0,22	kg PM10 eq / kg
Air	(unspecified)	Nitrogen oxides	0,22	kg PM10 eq / kg
Air	(unspecified)	NMVOC, non-methane volatile organic compounds, unspecified origin	0	kg PM10 eq / kg
Air	(unspecified)	Particulates, < 10 um	1	kg PM10 eq / kg
Air	(unspecified)	Particulates, < 10 um (mobile)	1	kg PM10 eq / kg
Air	(unspecified)	Particulates, < 10 um (stationary)	1	kg PM10 eq / kg
Air	(unspecified)	Particulates, < 2.5 um	1	kg PM10 eq / kg
Air	(unspecified)	Particulates, > 2.5 um, and < 10um	1	kg PM10 eq / kg
Air	(unspecified)	Sulfur dioxide	0,2	kg PM10 eq / kg
Air	(unspecified)	Sulfur monoxide	0,2	kg PM10 eq / kg
Air	(unspecified)	Sulfur oxides	0,2	kg PM10 eq / kg

SimaPro Database Manual

Methods Library

Colophon

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Contents

1 Introduction

SimaPro contains a number of impact assessment methods, which are used to calculate impact assessment results. This manual describes how the various impact assessment methods are implemented in SimaPro. For specific details on the method see the literature references given or contact the authors of the method.

AN IMPORTANT NOTE ON CHANGING METHODS
IF YOU WANT TO CHANGE METHODS IN SIMAPRO, IT IS STRONGLY ADVISED TO COPY THE ORIGINAL METHOD TO YOUR PROJECT. BY COPYING YOU MAKE SURE YOU ALWAYS HAVE AN ORIGINAL METHOD IN YOUR DATABASE. ONCE CHANGES ARE SAVED, THERE IS NO UNDO FUNCTION!

1.1 Structure of methods in SimaPro

The basic structure of impact assessment methods in SimaPro is:

1. Characterization
2. Damage assessment
3. Normalization
4. Weighting
5. Addition

The last four steps are optional according to the ISO standards. This means they are not always available in all methods. In SimaPro you can switch the optional steps on or off when you edit a method.

1.1.1 Characterization

The substances that contribute to an impact category are multiplied by a characterization factor that expresses the relative contribution of the substance. For example, the characterization factor for CO_2 in the Climate change impact category can be equal to 1, while the characterization factor of methane can be 25. This means the release of 1 kg methane causes the same amount of climate change as 25 kg CO_2. The total result is expressed as impact category indicators (formerly characterization results).

> ***Note:***
>
> 1. *A new substance flow introduced in ecoinvent 2.0 called 'carbon dioxide, land transformation' is included in all the methods available in SimaPro 8. This substance flow represents the CO_2 emissions from clear cutting and land transformation.*
> 2. *CO_2 uptake and emissions of CO_2 and CO from biogenic sources were removed from every method with effects on climate change. The characterization factors for methane from biogenic sources were corrected for the CO_2 sequestration.*

In SimaPro, sub-compartments can be specified for each substance. For example, you can define an emission to water with a sub-compartment of ocean. This allows you to create detailed impact assessment methods, with specific characterization factors for each sub-compartment.

Some impact assessment methods are not as detailed as the inventory in terms of specification of sub-compartments. In this case SimaPro will choose the "unspecified" characterization factor as the default factor for a substance that has a sub-compartment specified in the inventory but has no specific characterization factor in the chosen impact assessment method.

1.1.2 Damage assessment

Damage assessment is a relatively new step in impact assessment. It is added to make use of 'endpoint methods', such as the Eco-indicator 99 and the EPS2000 method. The purpose of damage assessment is to combine a number of impact category indicators into a damage category (also called area of protection).

In the damage assessment step, impact category indicators with a common unit can be added. For example, in the Eco-indicator 99 method, all impact categories that refer to human health are expressed in DALY (disability adjusted life years). In this method DALYs caused by carcinogenic substances can be added to DALYs caused by climate change.

1.1.3 Normalization

Many methods allow the impact category indicator results to be compared by a reference (or normal) value. This mean that the impact category is divided by the reference. A commonly used reference is the average yearly environmental load in a country or continent, divided by the number of inhabitants. However, the reference may be chosen freely. You could also choose the environmental load of lighting a 60W bulb for one hour, 100 km of transport by car or 1 liter of milk. This can be useful to communicate the results to non LCA experts, as you benchmark your own LCA against something everybody can imagine. In SimaPro, there are often alternative normalization sets available.

After normalization the impact category indicators all have the same unit, which makes it easier to compare them. Normalization can be applied on both characterization and damage assessment results.

PLEASE NOTE*: SimaPro does not divide by the reference value (N), but multiplies by the inverse. If you edit or add a normalization value in a method, you must therefore enter the inverted value (1/N).*

1.1.4 Weighting

Some methods allow weighting across impact categories. This means the impact (or damage) category indicator results are multiplied by weighting factors, and are added to create a total or single score. Weighting can be applied on normalized or non normalized scores, as some methods like EPS do not have a normalization step. In SimaPro, there are often alternative weighting sets available, always in combination with a normalization set.

1.2 Checking impact assessment results

Although impact assessment methods become very extensive and include more and more substances, they still do not cover all substances that you can find in your inventory. This can be a methodological issue, as some methods for example do not include raw materials as impact category. Issues can arise if you added a new substance that is not automatically included in the impact assessment method or if you introduced synonyms by importing data from other parties.

SimaPro has a built-in check to show you which substances are not included in the selected impact assessment method. For each result, the substances and their amounts *not included* in the method are shown under 'Checks' in the result window.

Further, under 'Inventory results' you can see the impact assessment results per substance. If a substance is not defined in the method, a pop-up hint will tell you this.

On a method level, you can run a check which will show you which of all substances, available in the SimaPro database, are included in the method on impact category level. To run this check, select a method and click the 'Check' button in the right hand side of the methods window.

SimaPro

2 European methods

2.1 CML-IA

In 2001, a group of scientists under the lead of CML (Center of Environmental Science of Leiden University) proposed a set of impact categories and characterization methods for the impact assessment step. The impact assessment method implemented as CML-IA methodology is defined for the midpoint approach. Normalization is provided but there is neither weighting nor addition.

There are two version of this method available in SimaPro 8: a 'baseline' version with 10 impact categories; and an extended version with 'all impact categories' including other impact categories as well as variations of existing impact categories, e.g. for different time frames.

The current version of CML-IA implemented in SimaPro has been updated using a version of the method uploaded in April 2013 from the website http://www.cml.leiden.edu/software/data-cmlia.html.

2.1.1 Classification and characterization

The CML Guide (Guinée et al. 2002) provides a list of impact assessment categories grouped into

A. Obligatory impact categories (category indicators used in most LCAs)

B. Additional impact categories (operational indicators exist, but are not often included in LCA studies)

C. Other impact categories (no operational indicators available, therefore impossible to include quantitatively in LCA)

In case several methods are available for obligatory impact categories; a baseline indicator is selected, based on the principle of best available practice. These baseline indicators are category indicators at "mid-point level" (problem oriented approach)" and are presented below. Baseline indicators are recommended for simplified studies. The guide provides guidelines for inclusion of other methods and impact category indicators in case of detailed studies and extended studies.

2.1.1.1 Depletion of abiotic resources

This impact category is concerned with protection of human welfare, human health and ecosystem health. This impact category indicator is related to extraction of minerals and fossil fuels due to inputs in the system. The Abiotic Depletion Factor (ADF) is determined for each extraction of minerals and fossil fuels (kg antimony equivalents/kg extraction) based on concentration reserves and rate of de-accumulation. The geographic scope of this indicator is at global scale.

2.1.1.2 Climate change

Climate change can result in adverse affects upon ecosystem health, human health and material welfare. Climate change is related to emissions of greenhouse gases to air. The characterization model as developed by the Intergovernmental Panel on Climate Change (IPCC) is selected for development of characterization factors. Factors are expressed as Global Warming Potential for time horizon 100 years (GWP100), in kg carbon dioxide/kg emission. The geographic scope of this indicator is at global scale.

2.1.1.3 Stratospheric Ozone depletion

Because of stratospheric ozone depletion, a larger fraction of UV-B radiation reaches the earth surface. This can have harmful effects upon human health, animal health, terrestrial and aquatic ecosystems, biochemical cycles and on materials. This category is output-related and at global scale. The characterization model is developed by the World Meteorological Organization (WMO) and defines ozone depletion potential of different gasses (kg CFC-11 equivalent/ kg emission). The geographic scope of this indicator is at global scale. The time span is infinity.

2.1.1.4 Human toxicity

This category concerns effects of toxic substances on the human environment. Health risks of exposure in the working environment are not included. Characterization factors, Human Toxicity Potentials (HTP), are calculated with USES-LCA, describing fate, exposure and effects of toxic substances for an infinite time horizon. For each toxic substance HTP's are expressed as 1,4-dichlorobenzene equivalents/ kg emission. The geographic scope of this indicator determines on the fate of a substance and can vary between local and global scale.

2.1.1.5 Fresh-water aquatic eco-toxicity

This category indicator refers to the impact on fresh water ecosystems, as a result of emissions of toxic substances to air, water and soil. Eco-toxicity Potential (FAETP) are calculated with USES-LCA, describing fate, exposure and effects of toxic substances. The time horizon is infinite Characterization factors are expressed as 1,4-dichlorobenzene equivalents/kg emission. The indicator applies at global/continental/ regional and local scale.

2.1.1.6 Marine ecotoxicity

Marine eco-toxicity refers to impacts of toxic substances on marine ecosystems (see description fresh water toxicity).

2.1.1.7 Terrestrial ecotoxicity

This category refers to impacts of toxic substances on terrestrial ecosystems (see description fresh water toxicity).

2.1.1.8 *Photo-oxidant formation*

Photo-oxidant formation is the formation of reactive substances (mainly ozone) which are injurious to human health and ecosystems and which also may damage crops. This problem is also indicated with “summer smog”. Winter smog is outside the scope of this category. Photochemical Ozone Creation Potential (POCP) for emission of substances to air is calculated with the UNECE Trajectory model (including fate), and expressed in kg ethylene equivalents/kg emission. The time span is 5 days and the geographical scale varies between local and continental scale.

2.1.1.9 *Acidification*

Acidifying substances cause a wide range of impacts on soil, groundwater, surface water, organisms, ecosystems and materials (buildings). Acidification Potential (AP) for emissions to air is calculated with the adapted RAINS 10 model, describing the fate and deposition of acidifying substances. AP is expressed as kg SO_2 equivalents/ kg emission. The time span is eternity and the geographical scale varies between local scale and continental scale.

Characterization factors including fate were used when available. When not available, the factors excluding fate were used (In the CML baseline version only factors including fate were used). The method was extended for Nitric Acid, soil, water and air; Sulphuric acid, water; Sulphur trioxide, air; Hydrogen chloride, water, soil; Hydrogen fluoride, water, soil; Phosphoric acid, water, soil; Hydrogen sulfide, soil, all not including fate. Nitric oxide, air (is nitrogen monoxide) was added including fate.

2.1.1.10 *Eutrophication*

Eutrophication (also known as nutrification) includes all impacts due to excessive levels of macro-nutrients in the environment caused by emissions of nutrients to air, water and soil. Nutrification potential (NP) is based on the stoichiometric procedure of Heijungs (1992), and expressed as kg PO_4 equivalents per kg emission. Fate and exposure is not included, time span is eternity, and the geographical scale varies between local and continental scale.

The method available with all impact categories has, comparing with the baseline version, the following impact categories available:

- Global warming (different time frames)
- Upper limit of net global warming
- Lower limit of net global warming
- Ozone layer depletion (different time frames)
- Human toxicity (different time frames)
- Fresh water aquatic ecotoxicity (different time frames)
- Marine aquatic ecotoxicity (different time frames)
- Terrestrial ecotoxicity (different time frames)
- Marine sediment ecotoxicity (different time frames)
- Average European (kg NO_x-eq); Average European (kg SO_2-eq)
- Land competition
- Ionising radiation
- Photochemical oxidation; Photochemical oxidation (low NO_x)

- Malodorous air
- Equal benefit incremental reactivity
- Max. incremental reactivity; Max. ozone incremental reactivity

2.1.2 Normalization

Normalization is regarded as optional for simplified LCA, but mandatory for detailed LCA. For each baseline indicator, normalization scores are calculated for the reference situations: the world in 1990, Europe in 1995 and the Netherlands in 1997. Normalization data are available for the Netherlands (1997/1998), Western Europe (1995) and the World (1990 and 1995) (Huijbregts et al. 2003).

References

Guinée, J.B.; Gorrée, M.; Heijungs, R.; Huppes, G.; Kleijn, R.; Koning, A. de; Oers, L. van; Wegener Sleeswijk, A.; Suh, S.; Udo de Haes, H.A.; Bruijn, H. de; Duin, R. van; Huijbregts, M.A.J. 2002. *Handbook on life cycle assessment. Operational guide to the ISO standards. Part III: Scientific background*. Kluwer Academic Publishers, ISBN 1-4020-0228-9, Dordrecht, 692 pp.

Huijbregts, M.A.J.; Breedveld L.; Huppes, G.; De Koning, A.; Van Oers, L.; Suh, S. 2003. *Normalisation figures for environmental life-cycle assessment: The Netherlands (1997/1998), Western Europe (1995) and the World (1990 and 1995)*. *Journal of Cleaner Production* 11 (7): 737-748.

2.2 Ecological scarcity 2013

The “ecological scarcity” method (also called Ecopoints or Umweltbelastungspunkte method) is a follow up of the Ecological scarcity 2006 (see section 6.9) and the Ecological scarcity 1997 method (see section 6.4) which was named Ecopoints 97 (CH) in the SimaPro method library.

The ecological scarcity method weights environmental impacts - pollutant emissions and resource consumption - by applying "eco-factors". The distance to target principle is applied in the Ecological scarcity method. The eco-factor of a substance is derived from environmental law or corresponding political targets. The more the current level of emissions or consumption of resources exceeds the environmental protection target set, the greater the eco-factor becomes, expressed in eco-points (EP = UBP). An eco-factor is essentially derived from three elements (in accordance with ISO Standard 14044): characterization, normalization and weighting.

The most important changes since last update are as follows:

- A reduction target of 80% has been set for CO_2 and other greenhouse gases. This falls in the upper range of the Swiss reduction target and within the range of the reduction required to achieve the 2°C target.
- To assess energy, the federal government's long-term target (2,000 W per capita) is interpolated to the usual time frame set out in the legislation, which is 2035.
- With regard to air pollutants, additional eco-factors are provided for PAHs and radioactive isotopes.
- In this version, PAHs, dioxins and furans, and benzene are all assessed for their carcinogenic potential.
- As for water pollutants, additional eco-factors for oil emissions to the sea are provided based on an international agreement to protect the North Sea. Furthermore, eco-factors for the emissions of radioactive isotopes and persistent organic pollutants in watercourses are included for the first time.
- In some parts of the world, freshwater is a scarce resource. The regionalized ecofactors introduced in the last update are now indicated for all countries and as determined on the basis of scarcity in OECD and BRIC countries (Brazil, Russia, India and China).
- It is now recommended that the eco-factor for freshwater be applied to consumptive water use (and not water extraction).
- In Switzerland, resource efficiency has become a relevant area of environmental policy. For that reason, a new eco-factor for mineral primary resources (minerals and metals) was introduced. The ratio of annual production to available reserves is used as the basis for the characterization.
- New eco-factors were introduced for land use in various biomes. Characterization is based on the impacts of land uses upon plant and animal biodiversity.
- New eco-factors are provided for noise pollution caused by road, rail and air traffic.

2.2.1 Characterization, normalization and weighting

In the ecological scarcity method, a characterization may be applied if the corresponding environmental impact played a key role when the target was set. Accordingly, the current CO_2 Act stipulates that all greenhouse gases must be taken into account. Therefore, it is both possible and appropriate to use global warming potential values. Characterization is not, however, appropriate in every theoretically conceivable case. It should not be used in cases where the environmental impact of the characterization does not match the legislators' intention with regard to the way the reduction target (or the limit or target value) was set.

The ecoinvent implementation contains nineteen specific impact categories, with for each substance a final UBP (environmental loading points) score as characterization factor which compile the characterization, normalization and distance-to-target weighting. The impact categories considered by this method are not defined as an impact indicator but rather as type of emission or resource:

1. Water sources
2. Energy sources
3. Mineral sources
4. Land use
5. Global warming
6. Ozone layer depletion
7. Main air pollutants and PM
8. Carcinogenic substances into air
9. Heavy metals into air
10. Water pollutants
11. POP into water
12. Heavy metals into water
13. Pesticides into soil
14. Heavy metals into soil
15. Radioactive substances into air
16. Radioactive substances into water
17. Noise
18. Non radioactive waste to deposit
19. Radioactive waste to deposit
20. Deposited waste

Weighting is conducted on the basis of goals set by Swiss environmental policy. In specific cases, global, international or regional goals are used and converted to the Swiss level. The method can also be applied to other countries and regions. To do so, information about the current environmental situation and the official environmental targets is required.

<u>References</u>

Frischknecht Rolf, Büsser Knöpfel Sybille, 2013: *Swiss Eco-Factors 2013 according to the Ecological Scarcity Method. Methodological fundamentals and their application in Switzerland*. Environmental studies no. 1330. Federal Office for the Environment, Bern: 254 pp.Bern 2013. www.bafu.admin.ch/uw-1330-e

2.3 EDIP 2003

EDIP 2003 is a Danish LCA methodology that is presented as an update of the EDIP 97 methodology.

The main innovation of EDIP2003 lies in the consistent attempt to include exposure in the characterization modelling of the main non-global impact categories. EDIP2003 can originally be used both with and without spatial differentiation. Only characterization factors for site-generic effects, which does not take spatial variation into account, are implemented in SimaPro 8.

2.3.1 Characterization

The EDIP 2003 methodology represents 19 different impact categories. Some of them are updated versions of EDIP 97, whereas others are modelled totally differently. Table 1 gives an overview of the EDIP 2003 impact categories. The choices made for implementing the methodology into SimaPro 8, are summed up for each impact category.

Impact categories:	**Implemented in original form**	**Choices made during implementation**
Global warming		Time horizon of 100y is used (IPPC, 2007)
Ozone depletion	x	
Acidification	x	
Terrestrial eutrophication	x	
Aquatic eutrophication (N-eq)		Only emissions to inland waters only are included. Emissions to air included
Aquatic eutrophication (P-eq)		
Ozone formation (human)	x	Extended with extra factors from EI 2.0
Ozone formation (vegetation)	x	Extended with extra factors from EI 2.0
Human toxicity (exposure route via air)		Release height of 25m
Human toxicity (exposure route via water)	x	
Human toxicity (exposure route via soil)	x	
Ecotoxicity (water acute)	x	
Ecotoxicity (water chronic)	x	
Ecotoxicity (soil chronic)	x	
Hazardous waste	Directly taken from EDIP 97 (update 2004)	
Slags/ashes	Directly taken from EDIP 97(update 2004)	
Bulk waste	Directly taken from EDIP 97(update 2004)	
Radioactive waste	Directly taken from EDIP 97(update 2004)	
Resources	Directly taken from EDIP 97(update 2004)	

Table 1: Overview of the different impact categories in EDIP2003, and the changes made for implementation.

In the EDIP 2003 method, characterization factors for aquatic eutrophication are developed for two impact categories: aquatic eutrophication (N-eq) and aquatic eutrophication (P-eq). In each impact category, characterization factors for emissions effecting inland waters and emissions effecting marine waters are developed. This double set of characterization factors reflects the fact that, in general, eutrophication is limited by nitrate in fresh waters, and phosphate in marine waters.

In order to avoid double counting, that would occur if both emission types are implemented simultaneously, only the characterization factors for inland water are implemented in SimaPro. When characterization factors for marine water are needed, the following list can be used and implemented in the EDIP 2003 method:

Substances	**CAS no.**	**Impact category**			
Emission to marine water		**Aquatic eutrophication**		**Aquatic eutrophication**	
Compartment		Soil	Water	Water	Soil
Nitric acid	7697-37-2	1,24E-01	1,61E-01	0,00E+00	0,00E+00
Nitrite	14797-65-0	1,62E-01	2,10E-01	0,00E+00	0,00E+00
Cyanide	57-12-5	2,92E-01	3,78E-01	0,00E+00	0,00E+00
Nitrogen, total		5,40E-01	7,00E-01	0,00E+00	0,00E+00
Phosphate	14265-44-2	0,00E+00	0,00E+00	3,30E-01	1,98E-02
Pyrophosphate	7722-88-5	0,00E+00	0,00E+00	3,50E-01	2,10E-02
Phosphorus, total		0,00E+00	0,00E+00	1,00E+00	6,00E-02

Table 2: Characterization factors for emissions to marine water in aquatic eutrophication. Emission compartment soil corresponds with the source category waste water while water corresponds with the source category agriculture.

The emission to soil only takes into account the effects after plant uptake. For this impact category the topsoil is part of the technosphere. Emissions to air are also included in the model. The data needed for this compartment is not present in the guideline, but is received from Michael Hauschild.

The EDIP2003 characterization factors for human toxicity, exposure route via air, are enhanced. The new exposure factors are established for:

- Two different kinds of substances: short-living (hydrogen chloride) and long-living (benzene)
- Actual variation in regional and local population densities: added for each substance
- Different release heights: 1m, 25m and 100m.

The release height of 25m is presented as default in EDIP2003 and is used in SimaPro.

2.3.2 Normalization

There are normalization factors provided for Europe in the reference year 2004 (Laurent et al. 2011).

2.3.3 Weighting

Until the EDIP weighting factors have been updated to an EDIP2003 version, the weighting factors of EDIP97 (according to the update issued in 2004), are also used in EDIP2003. Because ecotoxicity has no normalization factors, also for weighting the value is set at zero. For resources, normalization and weighing are already included in the characterization factor and therefore set at zero.

References

Frischknecht, R.; Jungbluth, N.; Althaus, H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

Hauschild, M.; Potting, J. 2003. *Spatial differentiation in Life Cycle impact assessment - The EDIP2003 methodology.* Institute for Product Development Technical University of Denmark.

Laurent, A.; Lautier, A.; Rosenbaum, R.K.; Olsen, S.I.; Hauschild, M.Z. 2011. *Normalization in EDIP97 and EDIP2003: updated European inventory for 2004 and guidance towards a consistent use in practice*. Int J LCA *16* (8): 728-738.

2.4 EPD (2013)

This method is the successor of EPD (2008) and is to be used for the creation of Environmental Product Declarations (EPDs), as published on the website of the Swedish Environmental Management Council (SEMC). An EPD is always created according to a Product Category Rule. This method is especially important for everybody who is reporting a Product Category Rule (PCR) published by Environdec.

2.4.1 Characterization

In the standard EPDs one only has to report on the following impact categories:

Original names	**Names in SimaPro**
Acidification potential	acidification (fate not included)
Eutrophication potential	eutrophication
Global warming potential	global warming'
Photochemical oxidant creation potential	photochemical oxidation'

Additional indicators:

The following impact categories are optional indicators and the inclusion of them should be specified in the PCR.

Original names	**Names in SimaPro**
Ozone-depleting gases (expressed as the sum of ozone-depleting potential in mass of CFC 11-equivalents, 20 years)	ozone layer depletion (ODP) (optional)
Abiotic resource depletion	Abiotic depletion (optional)

All impact categories are taken directly from the CML-IA baseline method (eutrophication, global warming and photochemical oxidation) and CML-IA non baseline method (acification). These two methods can be found in SimaPro as well.

2.4.2 Normalization and weighting

Normalization and weighting are not a part of this method.

References

General programme instructions for the international EPD® system, 2.01. 18 September 2013. Download at http://www.environdec.com/Documents/GPI/General_programme_instructions_2_01_20130918.pdf

2.5 EPS 2000

The EPS 2000 default methodology (Environmental Priority Strategies in product design) is a damage oriented method. In the EPS system, willingness to pay to restore changes in the safe guard subjects is chosen as the monetary measurement. The indicator unit is ELU (Environmental Load Unit), which includes characterization, normalization and weighting.

The top-down development of the EPS system has led to an outspoken hierarchy among its principles and rules. The general principles of its development are:

- The top-down principle (highest priority is given to the usefulness of the system);
- The index principle (ready-made indices represent weighted and aggregated impacts)
- The default principle (an operative method as default is required)
- The uncertainty principle (uncertainty of input data has to be estimated)
- Choice of default data and models to determine them

The EPS system is mainly aimed to be a tool for a company's internal product development process. The system is developed to assist designers and product developers in finding which one of two product concepts has the least impact on the environment. The models and data in EPS are intended to improve environmental performance of products. The choice and design of the models and data are made from an anticipated utility perspective of a product developer. They are, for instance not intended to be used as a basis for environmental protection strategies for single substances, or as a sole basis for environmental product declarations. In most of those cases additional site-specific information and modelling is necessary.

The EPS 2000 default method is an update of the 1996 version. The impact categories are identified from five safe guard subjects: human health, ecosystem production capacity, abiotic stock resource, biodiversity and cultural and recreational values.

This V2 version is adapted for SimaPro. All characterization factors in this method are entered for the 'unspecified' sub-compartment of each compartment (Raw materials, air, water, soil) and thus applicable on all sub-compartments, where no specific characterization value is specified.

This method is NOT fully adapted for inventory data from the Ecoinvent library and the USA Input Output Database 98, and therefore omits emissions that could have been included in impact assessment.

2.5.1 Classification and characterization

Emissions and resources are assigned to impact categories when actual effects are likely to occur in the environment, based on likely exposure. Empirical, equivalency and mechanistic models are used to calculate default characterization values.

2.5.1.1 Human Health

In EPS weighting factors for damage to human health are included for the following indictors:

- Life expectancy, expressed in Years of life lost (person year)
- Severe morbidity and suffering, in person year, including starvation
- Morbidity, in person year, like cold or flue
- Severe nuisance, in person year, which would normally cause a reaction to avoid the nuisance
- Nuisance, in person year, irritating, but not causing any direct action

2.5.1.2 Ecosystem production capacity

The default impact categories of production capacity of ecosystems are:

- Crop production capacity, in kg weight at harvest
- Wood production capacity, in kg dry weight
- Fish and meat production capacity, in kg full weight of animals
- Base cat-ion capacity, in H+ mole equivalents (used only when models including the other indicators are not available)
- Production capacity of (irrigation) water, in kg which is acceptable for irrigation, with respect to persistent toxic substances
- Production capacity of (drinking) water, in kg of water fulfilling WHO criteria on drinking water.

2.5.1.3 Abiotic stock resources

Abiotic stock resource indicators are depletion of elemental or mineral reserves and depletion of fossil reserves. Some classification factors are defined 0 (zero).

In SimaPro, characterization values for abiotic depletion result from both the impact of depletion and impacts due to extraction of the element/mineral or resource.

2.5.1.4 Biodiversity

Default impact category for biodiversity is extinction of species, expressed in Normalized Extinction of species (NEX).

2.5.1.5 *Cultural and recreational values*

Changes in cultural and recreational values are difficult to describe by general indicators as they are highly specific and qualitative in nature. Indicators should be defined when needed, and thus are not included in the default methodology in SimaPro.

2.5.2 Normalization/Weighting

In the EPS default method, normalization/weighting is made through valuation. Normalization/weighting factors represent the willingness to pay to avoid changes. The environmental reference is the present state of the environment. The indicator unit is ELU (Environmental Load Unit).

References

Steen B. 1999. *A systematic approach to environmental strategies in product development (EPS). Version 2000 - General system characteristics.* Centre for Environmental Assessment of Products and Material Systems. Chalmers University of Technology, Technical Environmental Planning. CPM report 1999:4.

2.6 Impact 2002+

IMPACT 2002+, acronym of IMPact Assessment of Chemical Toxics, is an impact assessment methodology originally developed at the Swiss Federal Institute of Technology - Lausanne (EPFL), with current developments carried out by the same team of researchers now under the name of Ecointesys-life cycle systems (Lausanne). The present methodology proposes a feasible implementation of a combined midpoint/damage approach, linking all types of life cycle inventory results (elementary flows and other interventions) via 14 midpoint categories to four damage categories (Figure 1).

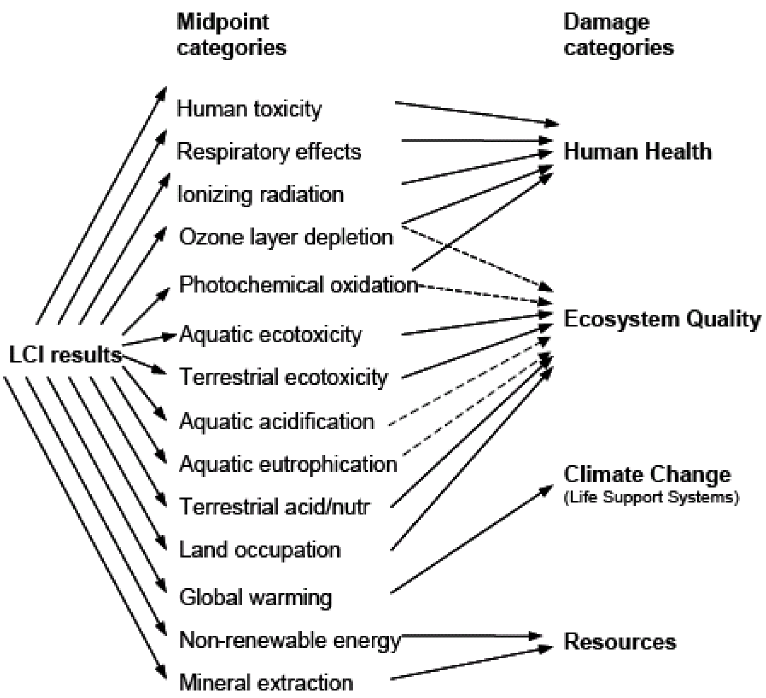

Figure 1 Overall scheme of the IMPACT 2002+ framework, linking LCI results via the midpoint categories to damage categories. Based on Jolliet et al. (2003a)

In SimaPro, only the characterization factors at endpoint level are provided.

2.6.1 Characterization

The characterization factors for human toxicity and aquatic and terrestrial ecotoxicity are taken from the methodology IMPACT 2002+. The characterization factors for other categories are adapted from existing characterizing methods, i.e. Eco-indicator 99, CML 2001, IPCC and the Cumulative Energy Demand.

The IMPACT 2002+ method (version 2.1) presently provides characterization factors for almost 1500 different LCI-results. In SimaPro, 15 different impact categories are presented, as human toxicity is split up in ‘Carcinogens’ and ‘Non-carcinogens’.

2.6.2 Normalization

The damage factor reported in ecoinvent are normalized by dividing the impact per unit of emission by the total impact of all substances of the specific category for which characterization factors exist, per person per year (for Europe). The unit of all normalized midpoint/damage factors is therefore [pers*year/$unit_{emission}$], i.e. the number of equivalent persons affected during one year per unit of emission.

2.6.3 Weighting

The authors of IMPACT2002+ suggest to analyze normalized scores at damage level considering the four-damage oriented impact categories human health, ecosystem quality, climate change, and resources or, alternatively, the 14 midpoint indicators separately for the interpretation phase of LCA. However, if aggregation is needed, one could use self-determined weighting factors or a default weighting factor of one, unless other social weighting values are available.

PRé added an extra weighting step. Each damage category is given the weighting factor 1.

References

Frischknecht, R.; Jungbluth, N.; Althaus, H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

Jolliet, O.; Margni, M.; Charles, R.; Humbert, S.; Payet, J.; Rebitzer, G.; Rosenbaum, R. 2003. *IMPACT 2002+: A New Life Cycle Impact Assessment Methodology*. Int J LCA 8 (6): 324 – 330.

2.7 ReCiPe

ReCiPe is the successor of the methods Eco-indicator 99 and CML-IA. The purpose at the start of the development was to integrate the 'problem oriented approach' of CML-IA and the 'damage oriented approach' of Eco-indicator 99. The 'problem oriented approach' defines the impact categories at a midpoint level. The uncertainty of the results at this point is relatively low. The drawback of this solution is that it leads to many different impact categories which makes the drawing of conclusions with the obtained results complex. The damage oriented approach of Eco-indicator 99 results in only three impact categories, which makes the interpretation of the results easier. However, the uncertainty in the results is higher. ReCiPe implements both strategies and has both midpoint (problem oriented) and endpoint (damage oriented) impact categories. The midpoint characterization factors are multiplied by damage factors, to obtain the endpoint characterization values.

ReCiPe comprises two sets of impact categories with associated sets of characterization factors. At the midpoint level, 18 impact categories are addressed:

1. Ozone depletion
2. Human toxicity
3. Ionizing radiation
4. Photochemical oxidant formation
5. Particulate matter formation
6. Terrestrial acidification
7. Climate change
8. Terrestrial ecotoxicity
9. Agricultural land occupation
10. Urban land occupation
11. Natural land transformation
12. Marine ecotoxicity
13. Marine eutrophication
14. Fresh water eutrophication
15. Fresh water ecotoxicity
16. Fossil fuel depletion
17. Minerals depletion
18. Fresh water depletion

At the endpoint level, most of these midpoint impact categories are multiplied by damage factors and aggregated into three endpoint categories:

- Human health
- Ecosystems
- Resource surplus costs

The three endpoint categories are normalized, weighted, and aggregated into a single score. Figure 2 sketches the relations between lifecycle inventory (LCI) parameters (left side), the 18 midpoint categories (middle), and the 3 endpoint categories, including the single score (right side).

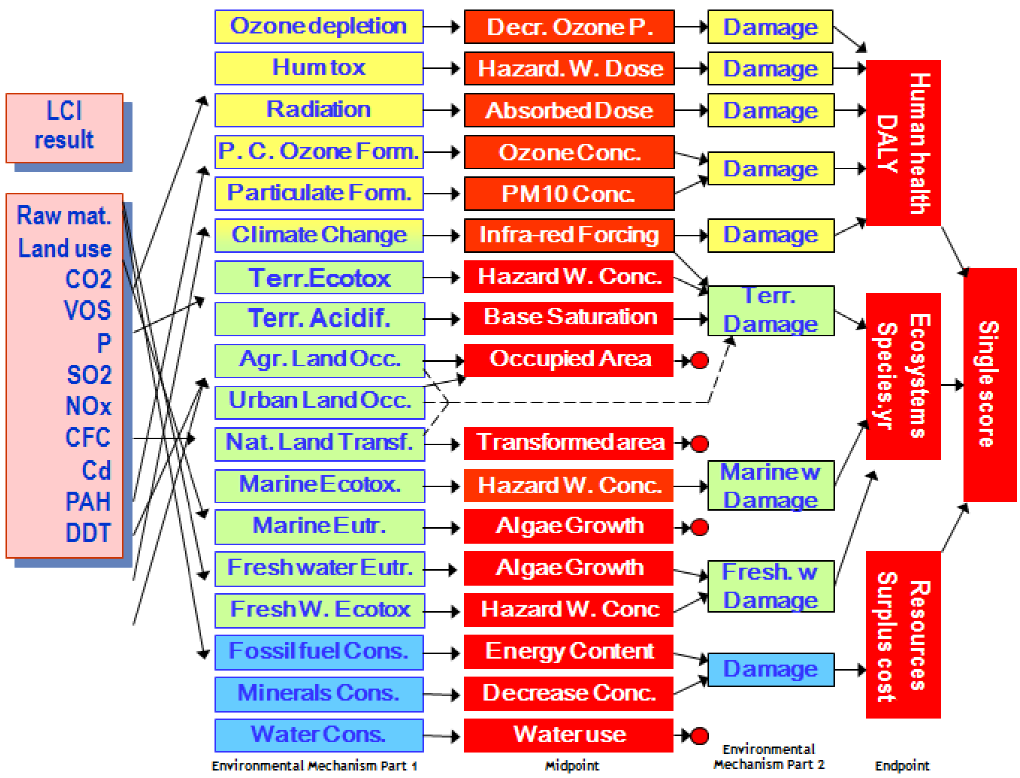

Figure 2: Representation of the relations between the inventory and the midpoint categories (environmental mechanisms) and the endpoint categories, including the single score (damage model).

2.7.1 Value choices

It is obvious that the environmental mechanisms and damage models are sources of uncertainty: the relationships modelled reflect state of the art knowledge of the environmental mechanisms that has a certain level of incompleteness and uncertainty. In ReCiPe, like in Eco-indicator 99, it was decided to group different sources of uncertainty and different (value) choices into a limited number of perspectives or scenarios, according to the "Cultural Theory" by Thompson 1990.

Three perspectives are discerned: individualist (I), hierarchist (H), and egalitarian (E). These perspectives do not claim to represent archetypes of human behaviour, but they are merely used to group similar types of assumptions and choices. For instance:

1. Perspective I is based on the short-term interest, impact types that are undisputed, technological optimism as regards human adaptation.
2. Perspective H is based on the most common policy principles with regards to time-frame and other issues.
3. Perspective E is the most precautionary perspective, taking into account the longest time-frame, impact types that are not yet fully established but for which some indication is available.

2.7.2 Characterization at midpoint level

2.7.2.1 Ozone depletion

The characterization factor for ozone layer depletion accounts for the destruction of the stratospheric ozone layer by anthropogenic emissions of ozone depleting substances (ODS). The unit is yr/kg CFC-11 equivalents.

2.7.2.2 Human toxicity and ecotoxicity

The characterization factor of human toxicity and ecotoxicity accounts for the environmental persistence (fate) and accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. The unit is yr/kg 1,4-dichlorobenzeen (14DCB).

2.7.2.3 Radiation

The characterization factor of ionizing radiation accounts for the level of exposure. The unit is yr/kg Uranium 235 equivalents.

2.7.2.4 Photochemical oxidant formation

The characterization factor of photochemical oxidant formation is defined as the marginal change in the 24h-average European concentration of ozone (*dCO3* in kg·m–3) due to a marginal change in emission of substance x (dMx in kg·year–1). The unit is yr/kg NMVOC.

2.7.2.5 Particulate matter formation

The characterization factor of particulate matter formation is the intake fraction of PM_{10}. The unit is yr/kg PM_{10} equivalents.

2.7.2.6 Climate change

The characterization factor of climate change is the global warming potential. The unit is yr/kg CO_2 equivalents.

2.7.2.7 Agricultural and urban land occupation

The amount of either agricultural land or urban land occupied for a certain time. The unit is m^2*yr.

2.7.2.8 Natural land transformation

The amount of natural land transformed and occupied for a certain time. The unit is m^2*yr.

2.7.2.9 Marine eutrophication

The characterization factor of marine eutrophication accounts for the environmental persistence (fate) of the emission of N containing nutrients. The unit is yr/kg N to freshwater equivalents.

2.7.2.10 Freshwater eutrophication

The characterization factor of freshwater eutrophication accounts for the environmental persistence (fate) of the emission of P containing nutrients. The unit is yr/kg P to freshwater equivalents.

2.7.2.11 Fossil fuel and minerals depletion

The characterization factor of fossil depletion is the amount of extracted fossil fuel extracted, based on the lower heating value. The unit is kg oil equivalent (1 kg of oil equivalent has a lower heating value of 42 MJ).

2.7.2.12 Minerals depletion

The characterization factor for minerals depletion is the decrease in grade. The unit is kg Iron (Fe) equivalents.

2.7.2.13 Freshwater depletion

The factor for the freshwater depletion is the amount of fresh water consumption. The unit is m^3.

2.7.3 Damage assessment

The endpoint characterization factors used in ReCiPe can be described as follows:

1. Human Health, expressed as the number of year life lost and the number of years lived disabled. These are combined as Disability Adjusted Life Years (DALYs), an index that is also used by the World Bank and WHO. The unit is years.
2. Ecosystems, expressed as the loss of species over a certain area, during a certain time. The unit is years.
3. Resources surplus costs, expressed as the surplus costs of future resource production over an infinitive timeframe (assuming constant annual production), considering a 3% discount rate. The unit is 2000US$.

2.7.4 Normalization

The normalization is based on the report of Sleeswijk et al. (2007). The normalization figures used in SimaPro are recalculated per citizen. The used population of EU25+3 is 464,036,294 citizens and the world has 6,055,000,000 citizens. Mineral use and the natural land transformation were not part of this project. Mineral use is based on data from USGS (2000). The source of the land transformation was FAO using the changes between 2000 and 2005.

2.7.5 Weighting

In this method, weighting is performed at damage category level (endpoint level in ISO terms). A panel performed weighting of the three damage categories. For each perspective, a specific weighting set is available. The average result of the panel assessment is available as weighting set.

The hierarchist version of ReCiPe with average weighting is chosen as default. In general, value choices made in the hierarchist version are scientifically and politically accepted.

References

Goedkoop, M.J.; Heijungs, R.; Huijbregts, M.A.J.; De Schryver, A.M.; Struijs, J.; Van Zelm, R. 2009. *ReCiPe 2008: A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level; First edition Report I: Characterisation*. 6 January 2009, http://www.lcia-recipe.net.

Sleeswijk, A.W.; van Oers, L.F.; Guinée, J.B.; Huijbregts, M.A.J. 2007. *Normalization in product life cycle assessment: An LCA of the global and European economic systems in the year 2000*. Sci Total Environ 390 (1):227-240.

SimaPro

2.8 ILCD 2011 Midpoint+

This is the corrected and updated method of the ILCD 2011 Midpoint (without the +) which can still be found in the Superseded folder. For this new version, the normalization factors were added as provided in "Normalisation method and data for Environmental Footprints; 2014; Lorenzo Benini, et al.; Report EUR 26842 EN". The characterization factors in the Land use category are updated based on "ERRATA CORRIGE to ILCD - LCIA Characterization Factors" - Version06_02_2015(v. 1.0.6) - "List of changes to CFs for land use from v 1 0 5 to v 1 0 6_REVISED.xlsx". Characterization factors for long term emissions are set to zero, because this was an implicit requirement from the European Commission. Weighting factors were added with equal weights for each of the recommended categories as indicated by the guidance document.

The full title of this method is: ILCD recommendations for LCIA in the European context. The European Commission (EC-JRC–IES, 2011) analyzed several methodologies for LCIA and made some effort towards harmonization. Starting from the first pre-selection of existing methods and the definition of criteria, a list of recommended methods for each impact category at both midpoint and endpoint was produced. The endpoint methods, however, are not included here, because the list is far from complete. Recommendations are given for the impact categories of climate change, ozone depletion, human toxicity, particulate matter/respiratory inorganics, photochemical ozone formation, ionizing radiation impacts, acidification, eutrophication, ecotoxicity, land use and resource depletion (Table 3). Research needs are identified for each impact category and differentiated according to their priority. No method development took place in the development of the ILCD recommendations. The intention was to identify and promote current best practice. These recommendations do not provide recommendations for weighting across impact categories, nor for normalization within a given category relative to impacts in a given region.

References

European Commission - Joint Research Centre. 2011. *International Reference Life Cycle Data System (ILCD) Handbook- Recommendations for Life Cycle Impact Assessment in the European context*. First edition November 2011. EUR 24571 EN. Luxemburg. Publications Office of the European Union; 2011

LCIA characterization factors release in February 2012 with errata from March 2012 can be downloaded from http://lct.jrc.ec.europa.eu/assessment/projects.

Impact category	Recommended default LCIA method	Indicator	Classification*
Climate change	Baseline model of 100 years of the IPCC	Radiative forcing as Global Warming Potential (GWP100)	I
Ozone depletion	Steady-state ODPs 1999 as in WMO assessment	Ozone Depletion Potential (ODP)	I
Human toxicity, cancer effects	USEtox model (Rosenbaum et al, 2008)	Comparative Toxic Unit for humans (CTUh)	II/III
Human toxicity, non- cancer effects	USEtox model (Rosenbaum et al, 2008)	Comparative Toxic Unit for humans (CTUh)	II/III
Particulate matter/Respiratory inorganics	RiskPoll model (Rabl and Spadaro, 2004) and Greco et al 2007	Intake fraction for fine particles (kg PM2.5-eq/kg)	I
Ionising radiation, human health	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	Human exposure efficiency relative to U235	II
Ionising radiation, ecosystems	No methods recommended		
Photochemical ozone formation	LOTOS-EUROS (Van Zelm et al, 2008) as applied in ReCiPe	Tropospheric ozone concentration increase	II
Acidification	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	Accumulated Exceedance (AE)	II
Eutrophication, terrestrial	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	Accumulated Exceedance (AE)	II
Eutrophication, aquatic	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe	Fraction of nutrients reaching freshwater end compartment (P)/ marine end compartment (N)	II
Ecotoxicity (freshwater)	USEtox model, (Rosenbaum et al, 2008)	Comparative Toxic Unit for ecosystems (CTUe)	II/III
Ecotoxicity (terrestrial and marine)	No methods recommended		
Land use	Model based on Soil Organic Matter (SOM) (Milà i Canals et al, 2007b)	Soil Organic Matter	III
Resource depletion, water	Model for water consumption as in Swiss Ecoscarcity (Frischknecht et al, 2008)	Water use related to local scarcity of water	III
Resource depletion, mineral, fossil and renewable**	CML 2002 (Guinée et al., 2002)	Scarcity	II

Table 3: Recommended methods and their classification at midpoint (ILCD 2011).

* Levels: “I” (recommended and satisfactory), level “II” (recommended but in need of some improvements) or level “III” (recommended, but to be applied with caution); “interim” indicates that a method was considered the best among the analyzed methods for the impact category, but still immature to be recommended.

** Depletion of renewable resources is included in the analysis but none of the analyzed methods is mature for recommendation

3 North American

3.1 BEES

BEES is the acronym for Building for Environmental and Economic Sustainability, a software tool developed by the National Institute of Standards and Technology (NIST). BEES combines a partial life cycle assessment and life cycle cost for building and construction materials into one tool. Results are presented in terms of life cycle assessment impacts, costs, or a combination of both as it can be seen in Figure 3. BEES strives to assist the architect, engineer, or purchaser choose a product that balances environmental and economic performance, thus finding cost-effective solutions for protecting the environment.

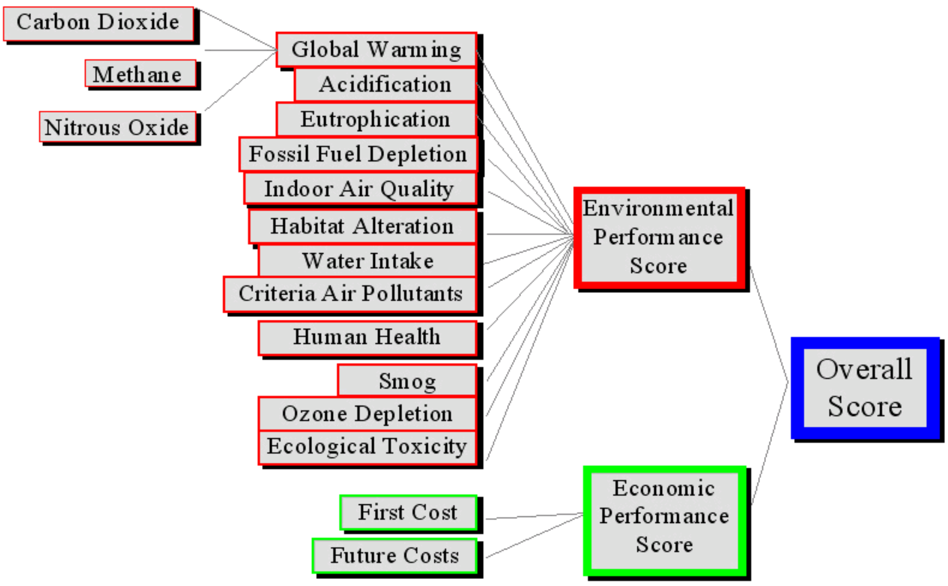

Figure 3 Structure of the BEES 4.0 methodology

3.1.1 Characterization

BEES uses the SETAC method of classification and characterization. The following six life cycle assessment impact categories are used by BEES:

1. global warming potential
2. acidification
3. eutrophication potential
4. natural resource depletion
5. solid waste
6. indoor air quality

Smog Characterization factors for two substances from equiv12.xls, biphenyl and diphenyl (both to air) have been averaged and assigned to biphenyl (air). Smog Characterization factors for Butane (C_4H_{10}) and Butane-n (n-C_4H_{10}) (both to air) have been averaged and assigned to Butane (air).

3.1.2 Normalization and weighting

Normalization is implemented as described in the report (Lippiatt, 2007) and weighting as described in Gloria et al. (2007).

References

Gloria, T.P.; Lippiatt, B.C.; Cooper, J. 2007. *Life Cycle Impact Assessment Weights to Support Environmentally Preferable Purchasing in the United States*. Environ Sci Technol *41* (21): 7551-7557.

Lippiatt, B.C. 2007. *BEES 4.0: Building for Environmental and Economic Sustainability. Technical Manual and User Guide*. NISTIR 7423. National Institute of Standards and Technology.

3.2 TRACI 2.1

The Tool for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI), a stand-alone computer program developed by the U.S. Environmental Protection Agency specifically for the US using input parameters consistent with US locations. Site specificity is available for many of the impact categories, but in all cases a US average value exists when the location is undetermined.

TRACI facilitates the characterization of environmental stressors that have potential effects, including ozone depletion, global warming, acidification, eutrophication, tropospheric ozone (smog) formation, ecotoxicity, human health criteria–related effects, human health cancer effects, human health non-cancer effects, fossil fuel depletion, and land-use effects. TRACI was originally designed for use with life-cycle assessment (LCA), but it is expected to find wider application in the future.

TRACI is a midpoint oriented life cycle impact assessment methodology, consistently with EPA's decision not to aggregate between environmental impact categories. It includes classification, characterization and normalization.

3.2.1 Characterization

Impact categories were characterized at the midpoint level for reasons including a higher level of societal consensus concerning the certainties of modelling at this point in the cause-effect chain. Research in the impact categories was conducted to construct methodologies for representing potential effects in the United States.

TRACI is a midpoint oriented LCIA method including the following impact categories:

- Ozone depletion
- Global warming
- Smog
- Acidification
- Eutrophication
- Carcinogenics
- Non carcinogenics
- Respiratory effects
- Ecotoxicity
- Fossil fuel depletion

3.2.2 Normalization

Morten Rybert from the Technical University of Denmark calculated normalization factors for the US and US + Canada. Data from 2008 and 2005 combined with 2008 was used for these reference geographies, respectively. A manuscript is now being prepared for publication at the International Journal of LCA.

References

Bare, J.; Gloria, T.; Norris, G. 2006. *Development of the Method and U.S. Normalization Database for Life Cycle Impact Assessment and Sustainability Metrics.* Environ Sci Techol *40* (16): 5108-5115.

Bare, J.C.; Norris, G.A.; Pennington, D.W.; McKone, T. 2003. *TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts.* Journal of Industrial Ecology. http://mitpress.mit.edu/journals/pdf/jiec_6_3_49_0.pdf

Frischknecht, R.; Jungbluth, N.; Althaus, H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

4 Single issue

4.1 Cumulative Energy Demand

The method to calculate Cumulative Energy Demand (CED) is based on the method published by Ecoinvent version 1.01 and expanded by PRé for energy resources available in the SimaPro database. Extra substances, according to the Ecoinvent database version 2.0, are implemented.

4.1.1 Characterization

Characterization factors are given for the energy resources divided in 5 impact categories:

1. Non renewable, fossil
2. Non renewable, nuclear
3. Renewable, biomass
4. Renewable, wind, solar, geothermal
5. Renewable, water

Normalization is not a part of this method. In order to get a total ("cumulative") energy demand, each impact category is given the weighting factor 1.

<u>References</u>

Frischknecht, R.; Jungbluth, N.; Althaus, H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

4.2 Cumulative Exergy Demand

The indicator Cumulative Exergy Demand (CExD) is introduced to depict total exergy removal from nature to provide a product, summing up the exergy of all resources required. CExD assesses the quality of energy demand and includes the exergy of energy carriers as well as of non-energetic materials. The exergy concept was applied to the resources contained in the ecoinvent database, considering chemical, kinetic, hydro-potential, nuclear, solar-radiative and thermal exergies. Details on the CExD method may be found in Bösch et al. (2007).

In order to quantify the life cycle exergy demand of a product, the indicator Cumulative Exergy Demand (CExD) is defined as the sum of exergy of all resources required to provide a process or product.

Exergy is another way to express quality of energy rather than energy content. Both are expressed in MJ. Exergy is a measure for the useful “work” a certain energy carrier can offer. For instance, natural gas has a high exergy value, as it can be used to create high temperatures and high pressured steam. If natural gas is used to heat a house in a highly efficient boiler, very little energy content is lost, but the exergy content is almost entirely lost (there is very little one can do with water between 50 and 80 degrees).

In this method exergy is used as a measure of the potential loss of “useful” energy resources.

This method has been directly taken from Ecoinvent 2.0. The amount of substances present is compatible with the EI 2.0 database and extended for other databases.

4.2.1 Characterization

The impact category indicator is grouped into the eight resource categories fossil, nuclear, hydropower, biomass, other renewables, water, minerals, and metals. However, in SimaPro, 10 different impact categories are presented:

- Non renewable, fossil
- Non renewable, nuclear
- Renewable, kinetic
- Renewable, solar
- Renewable, potential
- Non renewable, primary
- Renewable, biomass
- Renewable, water
- Non renewable, metals
- Non renewable, minerals

Exergy characterization factors for 112 different resources were included in the calculations.

$$CExD = \sum_i m_i * Ex_{(ch),i} + \sum_j n_j * r_{ex-e(k,p,n,r,t),j}$$

$CExD$	= cumulative exergy demand per unit of product or process (MJ-eq)
m_i	= mass of material resource i (kg)
$Ex_{(ch),i}$	= exergy per kg of substance i (MJ-eq/kg)
n_j	= amount of energy from energy carrier j (MJ)
$r_{ex-e(k,p,n,r,t),i}$	= exergy to energy ratio of energy carrier j (MJ-eq/MJ)
ch	= chemical
k	= kinetic
p	= potential
n	= nuclear
r	= radiative
t	= thermal exergy

The assignment of the adequate type of exergy depends on resource use:

- Chemical exergy is applied on all material resources, for biomass, water and fossil fuels (i.e. all materials that are not reference species in the reference state)
- Thermal exergy is applied for geothermy, where heat is withdrawn without matter extraction
- Kinetic exergy is applied on the kinetic energy in wind used to drive a wind generator
- Potential exergy is applied on potential energy in water used to run a hydroelectric plant
- Nuclear exergy is applied on nuclear fuel consumed in fission reactions
- Radiative exergy is applied on solar radiation impinging on solar panels

4.2.2 Normalization and weighting

Normalization is not a part of this method. In order to get a total (“cumulative”) exergy demand, each impact category is given the weighting factor 1.

References

Bösch, M.E.; Hellweg, S.; Huijbregts, M.A.J.; Frischknecht, R. 2007. *Applying Cumulative Energy Demand (CExD) Indicators to the ecoinvent Database.* In: Int J LCA *12* (3): 181–190.

Frischknecht, R.; Jungbluth, N.; Althaus, H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

4.3 Ecological Footprint

The ecological footprint is defined as the biologically productive land and water a population requires to produce the resources it consumes and to absorb part of the waste generated by fossil and nuclear fuel consumption.

4.3.1 Characterization

In the context of LCA, the ecological footprint of a product is defined as the sum of time integrated direct and indirect land occupation, related to nuclear energy use and to CO_2 emissions from fossil energy use:

$$EF = EF_{direct} + EF_{CO2} + EF_{nuclear}$$

4.3.2 Normalisation and weighting

Normalization is not a part of this method. In order to get a footprint, each impact category is given the weighting factor 1.

References

Frischknecht, R.; Jungbluth, N.; Althaus. H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

Wackernagel, M. 1994. *Ecological Footprint and Appropriated Carrying Capacity: A Tool for Planning Toward Sustainability* (PhD thesis). Vancouver, Canada: School of Community and Regional Planning. The University of British Columbia.

4.4 Ecosystem Damage Potential

The Ecosystem Damage Potential (EDP) is a life cycle impact assessment methodology for the characterization of land occupation and transformation developed by the Swiss Federal Institute of Technology (ETH), Zürich. It is based on impact assessment of land use on species diversity.

4.4.1 Characterization

This method was created using empirical information on species diversity from Central Europe. With information about species diversity on 5581 sample plots, Characterization factors for 53 land use types and six intensity classes were calculated. The typology is based on the CORINE Plus classification.

Linear transformations of the relative species numbers are linearly transformed into ecosystem damage potentials. The damage potential calculated is endpoint oriented.

The impact factor for the unknown reference land use type (ref) before or after the land transformation is chosen as EDP(ref) = 0.80. This represents the maximum EDP, i.e. the land use type with the most negative impact.

The different impact categories implemented in SimaPro are:

- “land transformation” as a result of the addition of “transformation, from land use type I” and “transformation, to land use type I”
- “land occupation”

Normalization is not a part of this method.

Because the two impact categories are expressed in the same unit (points), PRé added a weighting step. Each impact category is given the weighting factor 1.

References

Koellner, T.; Scholz, R. 2007. *Assessment of land use impact on the natural environment: Part 1: An Analytical Framework for Pure Land Occupation and Land Use Change.* Int J LCA *12* (1): 16-23.

4.5 Greenhouse Gas Protocol

The Greenhouse Gas Protocol (GHG Protocol), developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), is an accounting standard of greenhouse gas emissions. This method is based on the draft report on Product Life Cycle Accounting and Reporting Standard.

4.5.1 Characterization

To calculate carbon dioxide equivalents (CO_2eq) of all non-CO_2 gases (CH_4, N_2O, SF_6, HFCs, CFCs) the company shall use and report the most recent 100-year IPCC global warming potentials (GWP). The 100–year GWP is a metric used to describe the time-integrated radiative characteristics of well mixed greenhouse gases over a 100-year time horizon.

The total GHG emissions for a product inventory shall be calculated as the sum of GHG emissions, in CO_2eq, of all foreground processes and significant background processes within the system boundary. A distinction is made between:

- GHG emissions from fossil sources
- Biogenic carbon emissions
- Carbon storage
- Emissions from land transformation

According to the draft standard on product accounting, fossil and biogenic emissions must be reported independently. The reporting of the emissions from carbon storage and land transformation is optional.

4.5.2 Normalisation and weighting

Normalization and weighting are not a part of this method.

References

WBCSD & WRI. 2009. *Product Life Cycle Accounting and Reporting Standard. Review Draft for Stakeholder Advisory Group.* The Greenhouse Gas Protocol Initiative. November 2009.

4.6 IPCC 2013

IPCC 2013 is an update of the method IPCC 2007 developed by the International Panel on Climate Change. This method lists the climate change factors of IPCC with a timeframe of 20, 100 and 500 years.

4.6.1 Characterization

IPCC characterization factors for the direct (except CH_4) global warming potential of air emissions. They are:

- not including indirect formation of dinitrogen monoxide from nitrogen emissions.
- not accounting for radiative forcing due to emissions of NOx, water, sulphate, etc. in the lower stratosphere + upper troposphere.
- not considering the range of indirect effects given by IPCC.
- not including CO_2 formation from CO emissions.

4.6.2 Normalisation and weighting

Normalization and weighting are not a part of this method.

References

Intergovernmental Panel on Climate Change. 2007. *IPCC Fifth Assessment Report. The Physical Science Basis*. http://www.ipcc.ch/report/ar5/wg1/.

4.7 Selected LCI results

The selected life cycle inventory indicators are, in most cases, the summation of selected substances emitted to all different sub-compartments.

4.7.1 Classification

The list of selected LCI indicators is divided in two. The first list contains the common set of elementary flows shown in the results discussion of the ecoinvent reports. One example is "fossil CO_2 emissions to air". The second list contains additional elementary flows used in at least one of the ecoinvent reports (Table 4). One example of this extended list is "actinides emitted to water". These two lists are implemented as two different methods into SimaPro: Selected LCI results and Selected LCI results, additional.

The selection does not necessarily reflect the environmental importance of the listed pollutants and resources. The pollutants and resources are selected in view of a better characterization of the analyzed products and services.

The selection helps practitioners to get a more convenient access to a selection of LCI results of products and services. It does not replace the use of the complete set of LCI results and the application of LCIA methods.

References

Frischknecht, R.; Jungbluth, N.; Althaus, H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

Subcategory	**Name**	**Location**	**Unit**	**Used in ecoinvent report**
resource	land occupation	GLO	m2a	all
resource	water	GLO	m^3	No. 6 VIII
resource	carbon, biogenic, fixed	GLO	kg	No. 17
air	carbon monoxide	GLO	kg	No. 11 II
air	CO_2, fossil	GLO	kg	all
air	lead	GLO	kg	No. 6 VI
air	methane	GLO	kg	No. 6 IV
air	N2O	GLO	kg	No. 6 VI
air	nitrogen oxides	GLO	kg	all
air	NMVOC	GLO	kg	all
air	particulates, <2.5 um	GLO	kg	all
air	particulates, >2.5 um and <10 um	GLO	kg	No. 6 VI
air	particulates, >10 um	GLO	kg	No. 6 VI
air	particulates	GLO	kg	No. 11 II
air	sulphur dioxide	GLO	kg	all
air	zinc	GLO	kg	No. 6 VI
air, radioactive	radon (+ radium)	GLO	kBq	No. 6 VI
air, radioactive	noble gas	GLO	kBq	No. 6 VI
air, radioactive	aerosol	GLO	kBq	No. 6 VI
air, radioactive	actinides	GLO	kBq	No. 6 VI
soil	cadmium	GLO	kg	all
water	BOD	GLO	kg	all
water, radioactive	radium	GLO	kBq	No. 6 VII
water, radioactive	tritium	GLO	kBq	No. 6 VII
water, radioactive	nuclides	GLO	kBq	No. 6 VII
water, radioactive	actinides	GLO	kBq	No. 6 VII
total	oils, unspecified	GLO	kg	No. 6 IV
total	heat, waste	GLO	MJ	No. 6 VII

Table 4: List of selected life cycle inventory indicators implemented in ecoinvent data v2.0.

4.8 USEtox

The USEtox model is an environmental model for characterization of human and eco-toxicological impacts in Life Cycle Impact Assessment and Comparative Risk Assessment. It has been developed by a team of researchers from the Task Force on Toxic Impacts under the UNEP-SETAC Life Cycle Initiative (see www.usetox.org). USEtox is designed to describe the fate, exposure and effects of chemicals. The UNEP-SETAC Life Cycle Initiative supports the development, evaluation, application, and dissemination of USEtox to improve understanding and management of chemicals in the global environment. This method is officially still under review.

4.8.1 Characterization

Life cycle impact assessment (LCIA) aims to improve the understanding of the relative importance of the individual emissions in life-cycle inventories. This is done using a weighted summation of the releases of pollutants of a product system with help of characterization factors:

$$IS = \sum_i \sum_x CF_{x,i} \cdot M_{x,i}$$

where *IS* is the impact score for e.g. human toxicity (cases); $CF_{x,i}$ the characterization of substance *x* released to compartment *i* (cases/kg) and $M_{x,i}$ the emission of x to compartment *i* (kg). The summation holds for substances and emission compartments.

The USEtox method has used two sub-compartments per compartment. The list of the correspondence of the sub-compartments used by SimaPro and the ones used by USEtox is presented in Table 5.

The USEtox model calculates characterization factors for carcinogenic impacts, non-carcinogenic impacts, and total impacts (Carc + non-carc) for chemical emissions to urban air, rural air, freshwater, sea water, agricultural soil and/or natural soil. The unit of the characterization factor for freshwater aquatic ecotoxicity is PAF.m^3.day/$kg_{emission}$ and for human toxicity cases/$kg_{emission}$ both summarized as Comparative Toxic Unit (CTU) to stress the comparative nature of the characterization factors.

The provided characterization factors have been classified as:

- Recommended
- Interim

Recommended factors are given for substances where the USEtox™ model is considered fully appropriate and the underlying substance data is of sufficient quality to support a recommendation. In cases where relatively high uncertainty in addressing fate, exposure and/or effects of a chemical is expected, we label the characterization factor as ‘interim’. This recommendation is given in cases where the substance is a metal or an inorganic chemical, an organometallic chemical, an amphiphilic chemical (e.g. detergents) or dissociating under environmental conditions. It is also recommended that aquatic eco-toxicological characterization factors are specified as interim, if effect factors are based on species toxicity data covering less than three different trophic levels. This is to ensure a minimum variability of biological responses.

	SimaPro compartments	USEtox compartments		
Air	(unspecified)	*50 Em.airU / 50 Em.airC*	50/50 urban/continental	Estimated
Air	high. pop.	*Em.airU*	Urban air	Calculated
Air	low. pop.	*Em.airC*	Continental air	Calculated
Air	low. pop., long-term	*Em.airC*	Continental air	Estimated
Air	stratosphere + troposphere	*Em.airC*	Continental air	Estimated
Water	(unspecified)	*Em.fr.waterC*	Freshwater	Estimated
Water	river	*Em.fr.waterC*	Freshwater	Calculated
Water	river, long-term	*Em.fr.waterC*	Freshwater	Estimated
Water	lake	*Em.fr.waterC*	Freshwater	Calculated
Water	ocean	*Em.sea waterC*	Sea water	Calculated
Soil	agricultural	*Em.agr.soilC*	Agri. Soil	Calculated
Soil	(unspecified)	*Em.nat.soilC*	Natural soil	Estimated
Soil	forestry	*Em.nat.soilC*	Natural soil	Calculated

Table 5. List of correspondence of SimaPro and USEtox sub-compartments.

Following recommendations of the USEtox developers, the following rules have been followed for the characterization factors for inorganic emissions:

i. Antimony: The CFs of Sb(+V) are used to represent the CFs for the unspecified form of Sb (ionic and metallic).

ii. Arsenic: The CFs of As(+V) are used to represent the CFs for the unspecified form of As (ionic and metallic).

iii. Chromium: The CFs for generic Cr are defined as 50% of CF for Cr(+III) and 50% of CF for Cr(+VI). Since it is not specified which oxidized form is considered for chromium ion, the same method is applied to generic chromium ion.

<u>What version should you use?</u>

The version Recommended + interim should be used. The version including only the Recommended characterization factors is only provided for purposes of sensitivity analysis.

4.8.2 Normalization

Laurent et al. (2011) developed normalization references for Europe and North America for application with USEtox characterization factors. The base years of the European and North American inventories are 2004 and 2002/2008, respectively. The two inventory sets were characterized with the USEtox™ model with both recommended and interim characterization factors. This version, referred in SimaPro as "default", includes normalization factors. The version intended for sensitivity analysis which only includes the recommended characterization factors only includes the characterization step.

References

Hauschild, M., Huijbregts, M., Jolliet, O., Macleod, M., Margni, M., van de Meent, D., Rosenbaum, R., McKone, T. 2008. *Building a Model Based on Scientific Consensus for Life cycle Impact Assessment of Chemicals: The Search for Harmony and Parsimony.* Environ Sci & Techn, *42* (19), pp 7032-7037.

Laurent, A.; Lautier, A.; Rosenbaum, R.K.; Olsen, S.I.; Hauschild, M.Z. 2011. *Normalization references for Europe and North America for application with USEtox™ characterization factors*. Int J LCA *16* (8): 728-738.

Rosenbaum, R.K.; Huijbregts, M.A.J.; Henderson, A.D.; Margni, M.; McKone, T.E.; van de Meent, D.; Hauschild, M.Z.; Shaked, S.; Li, D.S.; Gold, L.S.; Jolliet, O. 2011. *USEtox human exposure and toxicity factors for comparative assessment of toxic emissions in life cycle analysis: sensitivity to key chemical properties*. Int J LCA *16* (8): 710-727.

Rosenbaum, R.K.; Bachmann, T.M.; Gold L.S.; Huijbregts, M.A.J.; Jolliet, O.; Juraske, R.; Koehler, A.; Larsen, H.F.; MacLeod, M.; Margni, M.; McKone, T.E.; Payet, J.; Schuhmacher, M.; van de Meent, D.; Hauschild, M.Z. 2008. *USEtox – the UNEP-SETAC toxicity model: recommended characterization factors for human toxicity and freshwater ecotoxicity in life cycle impact assessment*. Int J LCA *13* (7): 532-546.

USEtox™. 2009. Retrieved from www.usetox.org.

5 Water Footprint

5.1 Boulay et al 2011 (Human Health)

This method is based on the publication Boulay et al (2011).

The method is an endpoint indicator expressed in DALY and is obtained by modelling each water user's loss of functionality. It addresses three different impact pathways:

1) malnutrition from water deprivation for agricultural users,
2) malnutrition from water deprivation for fisheries, and
3) water-related diseases associated with a lack of water for domestic use.

The cause-effect chain modelling is based on hydrological and socio-economic data. The water scarcity index is used at the midpoint level [Boulay et al 2011 (Water Scarcity)]. The level of economic development is considered through the adaptation capacity based on gross national income.

The method contains two different types of human health categories: distribution and marginal.

Distribution effects apply to all types of water consumption. Distribution refers to the impact assessment in which all users are competing and proportionally affected according to their distributional share of water use for off-stream users (here, agriculture, fisheries and domestic).

Marginal effects apply to agricultural water consumption. Marginal refers to a modelling choice in which any additional water use will deprive only one off-stream user (agricultural).

The "HH, marginal" category is comparable with the "HH, agricultural water scarcity" category in the Motoshita et al 2010 (Human Health) method and the "Human Health" category of the Pfister et al 2009 (Eco-indicator 99) and Pfister et al 2010 (ReCiPe) methods. Note that the "HH, distribution" category includes more effects and is NOT complementary to the "HH, marginal" category.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterisation factors for some countries.

References

Boulay, A.M., Bulle, C., Bayart, J.B., Deschenes, L., Margni, M. (2011). *Regional Characterization of Freshwater Use in LCA: Modeling Direct Impacts on Human Health.* Environmental Science & Technology 45: 8948-8957.

5.2 Boulay et al 2011 (Water Scarcity)

This method is based on the publication Boulay et al (2011).

This water scarcity indicator (WSI) method is based on a consumption to availability (CTA) ratio and modelled using a logistic function (S-curve) in order to fit the resulting indicator to values between 0 and 1 m^3 deprived/m^3 consumed. The curve is tuned using OECD water stress thresholds, which define moderate and severe water stress as 20% and 40% of withdrawals, respectively and converted with an empirical correlation between withdrawal to availability (WTA) and CTA. The scarcity indicators are also available for surface and groundwater. Water consumption and availability data are taken from the WaterGap model. The indicator is applied to the consumed water volume and assesses consumptive water use only.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterisation factors for some countries.

References

Boulay, A.M., Bulle, C., Bayart, J.B., Deschenes, L., Margni, M. (2011). *Regional Characterization of Freshwater Use in LCA: Modeling Direct Impacts on Human Health.* Environmental Science & Technology 45: 8948-8957.

5.3 Ecological Scarcity 2006 (Water Scarcity)

This method is taken from http://www.esu-services.ch/projects/ubp06/ (23-May 2008), with adaptations by PRé as described below. The characterisation factors have first been implemented by ESU-services Ltd. All files are provided without liability.

Contact info: http://www.esu-services.ch/address/

Ecological Scarcity 2006 is a follow up of the Ecological scarcity 1997 method, which is called Ecopoints 97 (CH) in the SimaPro method library (superseded). The ecoinvent implementation contains seven specific impact categories, with for each substance a final UBP (environmental loading points) score as characterisation factor. This method only contains the impact category Natural resources containing only water resources. The complete method can be found in the European methods category.

5.4 Hoekstra et al 2012 (Water Scarcity)

This method is based on the publication Hoekstra et al (2012).

This water scarcity indicator (WSI) is based on a consumption-to-availability ratio (CTA) calculated as the fraction between consumed (referred to as blue water footprint) and available water. The latter considers all runoff water, of which 80% is subtracted to account for environmental water needs. The data is from Fekete et al. 2002 for water runoff and Mekonnen et al. for water consumption. Results are available for the main watersheds worldwide but many outlying regions are not covered. The indicator is applied to the consumed water volume and only assesses consumptive water use.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterization factors for some countries.

References

Hoekstra AY, Mekonnen MM, Chapagain AK, Mathews RE, Richter BD (2012) *Global Monthly Water Scarcity: Blue Water Footprints versus Blue Water Availability.* PLoS ONE 7(2): e32688. doi:10.1371/journal.pone.0032688

5.5 Motoshita et al 2011 (Human Health)

This method is based on the publication Motoshita et al (2011).

The method is an endpoint indicator. It contains two different types of human health categories: one for infectious disease damage caused by domestic water scarcity and one for malnutrition damage caused by agricultural water scarcity.

For domestic water scarcity, the method assumes that water resource scarcity caused by water consumption will lead to a loss of access to safe water. The cause-effect chain modelling is based on hydrological and socio-economic data. The water scarcity index used at the midpoint is Pfister et al 2009 (Water Scarcity). The level of economic development is considered through the parameter house connection to water supply.

The impacts of malnutrition caused by agricultural water deficit are modelled using the same data source for scarcity and distribution as above, multiplied by a socio-economic parameter describing the trade effect. This illustrates how food supply shortage in a country will spread to other countries through international food trade. Countries with low and middle incomes will be affected by the food shortage. This effect is quantified in DALY by using malnutrition-related DALYs in the importing countries (DALYs/kcal malnutrition).

The "HH, agricultural water scarcity" category is comparable with the "HH, marginal" category of Boulay et al 2011 (Human Health) and the "Human Health" category of the Pfister et al 2009 (Eco-indicator 99) and Pfister et al 2010

(ReCiPe) methods. The "HH, domestic water scarcity" category is complementary to the "HH, agricultural water scarcity" category.

The method provides country-based characterization factors in the context of both domestic and agricultural water scarcity, expressed in DALY per m^3 of water consumed.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterisation factors for some countries.

References

Motoshita, M., Itsubo, N., Inaba, A. (2011). *Development of impact factors on damage to health by infectious diseases caused by domestic water scarcity.* Int J LCA 16, 65-73.

5.6 Pfister et al 2009 (Eco-indicator 99)

This method is based on the publication Pfister et al (2009). The method is based on the same endpoint categories as in the Eco-indicator 99 method.

Human health is obtained by modelling the cause-effect chain of water deprivation for agricultural users (lack of irrigation water) leading to malnutrition. It builds on the midpoint scarcity indicator [Pfister et al 2009 (Water Scarcity)] and models the cause-effect chain by multiplying it by:

- the agricultural users' share of water use from Vorosmarty,
- a socio-economic parameter defined as a human development factor for malnutrition, which relates the Human Development Index and
- two values independent of location combined in an effect factor that describes the DALY/m^3 of water deprived for agriculture: the per-capita water requirements to prevent malnutrition (in m^3/(yr•capita)) and the damage factor denoting the damage caused by malnutrition (DALY/(yr•capita)).

Ecosystem quality is obtained by modelling the cause-effect chain of freshwater consumption on terrestrial ecosystem quality and assessed following the Eco-indicator 99 method, with units of potentially disappeared fraction of species (PDF). The fraction of net primary productivity (NPP) which is limited by water availability represents the water-shortage vulnerability of an ecosystem, and is used as a proxy for PDF.

Resources is obtained by modelling the cause -effect chain of freshwater consumption on water resource depletion. The back-up technology concept is used following the Eco-indicator 99 method. The damage to resources resulting from water consumption is calculated by multiplying the energy demand for desalination by the fraction of water consumption contributing to freshwater depletion, which is dependent on the withdrawal to availability (WTA) ratio. The unit is expressed in surplus energy (MJ).

The "Human Health" category is comparable with the "HH, marginal" category in the Boulay et al 2011 (Human Health) method the "HH, agricultural water scarcity" category in the Motoshita et al 2010 (Human Health) method.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterisation factors for some countries.

References

Pfister, S.; Koehler, A.; Hellweg, S. (2009). *Assessing the environmental impacts of freshwater consumption in LCA.* Environmental Science and Technology, 43(11), 4098–4104; DOI: 10.1021/es802423e (download: http://pubs.acs.org/doi/full/10.1021/es802423e)

5.7 Pfister et al 2009 (Water Scarcity)

This method is based on the publication Pfister et al (2009). This water scarcity indicator (WSI) is based on a withdrawal to availability (WTA) ratio and modelled using a logistic function (S-curve) in order to fit the resulting indicator to values between 0.01 and 1 m^3 deprived/m^3 consumed. The curve is tuned using OECD water stress thresholds, which define moderate and severe water stress as 20% and 40% of withdrawals, respectively. Data for water withdrawals and availability were obtained from the WaterGap model. The indicator is applied to the consumed water volume and assesses consumptive water use only.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterisation factors for some countries.

References

Pfister, S.; Koehler, A.; Hellweg, S. (2009). *Assessing the environmental impacts of freshwater consumption in LCA.* Environmental Science and Technology, 43(11), 4098–4104; DOI: 10.1021/es802423e (download: http://pubs.acs.org/doi/full/10.1021/es802423e)

5.8 Pfister et al 2010 (ReCiPe)

This method is based on the publication Pfister et al (2010). The method is based on the same endpoint categories as in the ReCiPe method.

Human health is expressed in DALY and is obtained by modelling the cause-effect chain of water deprivation for agricultural users (lack of irrigation water) leading to malnutrition. The cause-effect chain modelling is based on hydrological and socioeconomic data. The water scarcity index is used at the midpoint [Pfister et al 2009 (Water Scarcity)]. The level of economic development is considered though the parameter Human Development Index.

Ecosystem quality is obtained by modelling the cause-effect chain of freshwater consumption on terrestrial ecosystem quality and assessed following ReCiPe, with units of disappeared species per year.

Resources is obtained by modelling the cause-effect chain of freshwater consumption on water resource depletion following ReCiPe, with units of surplus cost to extract an additional cubic meter of water.

The "Human Health" category is comparable with the "HH, marginal" category in the Boulay et al 2011 (Human Health) method the "HH, agricultural water scarcity" category in the Motoshita et al 2010 (Human Health) method.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterisation factors for some countries.

References

Pfister, Stephan; Saner, Dominik; Koehler, Annette (2010). The *environmental relevance of freshwater consumption in global power production.* The International Journal of Life Cycle Assessment 2011, 16, 580-591.

5.9 Berger et al 2014, WAVE (Water Scarcity)

This method is based on the publication Berger *et al* (2014).

The method analyzes the vulnerability of basins to freshwater depletion. Based on local blue water scarcity, the water depletion index (WDI) denotes the risk that water consumption can lead to depletion of freshwater resources. Water scarcity is determined by relating annual water consumption to availability in more than 11 000 basins. Additionally, WDI accounts for the presence of lakes and aquifers which have been neglected in water scarcity assessments so far. By setting WDI to the highest value in (semi)arid basins, absolute freshwater shortage is taken into account in addition to relative scarcity. This avoids mathematical artifacts of previous indicators which turn zero in deserts if consumption is zero.

The regional factors are weighted averages based on the freshwater withdrawal by country data from the Pacific Institute (http://www2.worldwater.org/data.html).

After calculating your results we recommend you view the 'Checks' tab to see if there are any significant flows omitted due to the incomplete list of characterisation factors for some countries.

References

Markus Berger, Ruud van der Ent, Stephanie Eisner, Vanessa Bach, and Matthias Finkbeiner. 2014. *Water Accounting and Vulnerability Evaluation (WAVE): Considering Atmospheric Evaporation Recycling and the Risk of Freshwater Depletion in Water Footprinting.* Environ. Sci. Technol., 2014, 48 (8), pp 4521–4528.

6 Superseded

This section includes methods which have been updated or replaced by a newer version. We recommend therefore not using these but instead the methods presented in sections 2, 3 **and** 0**.**

6.1 CML 1992

This classification method is based on the method published by CML of the University of Leiden in October 1992[1].

PRé has modified the method: the depletion and energy classes were separated and the classes for smell and biotic exhaustion were excluded.

This v2 version is adapted for SimaPro 8. All characterization factors in this method are entered for the 'unspecified' sub-compartment of each compartment (Raw materials, air, water, soil) and thus applicable on all sub-compartments.

This method is NOT fully adapted for inventory data from the Ecoinvent library and the USA Input Output Database 98, and therefore omits emissions that could have been included in impact assessment.

6.1.1 Characterization

Grouped substances or sum parameters have been defined in a number of classes. This has been done because the emissions are not always specified separately in the data sources for the processes concerned. Emissions are often specified under a collective name, e.g. aromatic hydrocarbons. Since the different substances within such a group can have considerable variation in their environmental impact, the resulting effect score may not be completely reliable.

The main classes are: 1. Exhaustion of raw materials and energy, and 2. Pollution.

1. Exhaustion of raw materials and energy

Abiotic

This term refers to energy sources and a number of scarce metals. In the CML 92 method, all the energy sources were grouped into a separate class called Energy.

The effect score for exhaustion is calculated on the following basis:

Exhaustion = (amount consumed (kg) x {1/resources (kg)})^2

[1] R. Heijungs et al, *Environmental life cycle assessment of products, Guide, October 1992* CML, Leiden, The Netherlands, NOH report 9266.

Biotic

This category is intended for rare animals and plants. This score is as yet very rudimentary and has therefore not been used.

2. Pollution

6.1.1.1 Greenhouse effect

The Global Warming Potential (GWP) is the potential contribution of a substance to the greenhouse effect. This value has been calculated for a number of substances over periods of 20, 100 and 500 years because it is clear that certain substances gradually decompose and will become inactive in the long run. For the CML 92 method, we have taken the GWP over a 100-year period because this is the most common choice.

We have added values for CFC (hard) and for CFC (soft) to the CML (1992) method, since it is not always known which CFC is released. The GWP for this category of substances has been equated to that of CFCs frequently used in industrial mass and series production; for CFC (hard) this is the value for CFC-12, and for CFC (soft) it is the value for HCFC-22.

The effect score for the greenhouse effect is calculated per substance as follows:

Greenhouse effect (kg) = (GWP 100 x airborne emission (kg))[3]

6.1.1.2 Ozone layer depletion

Ozone Depletion Potential (ODP) values have been established mainly for hydrocarbons containing combined bromine, fluorine and chlorine, or CFCs. Here too, one of the substances (CFC-11) has been adopted as a reference. As for the greenhouse effect, we have added values for CFC (hard) and CFC (soft). The ODP equivalents for these groups are again those of CFC-12 and HCFC-22 respectively.

The effect score for ozone layer depletion is calculated as follows:

Ozone layer depletion (kg) = (ODP x airborne emission (kg))[4]

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[2] World Institute, *World Resources 1990-1991,* Oxford University Press, New York/Oxford.

[3] Houghton, Callender & Varney, *Climate Change 1992. The supplementary report to the IPCC scientific assessment*, Cambridge University Press, Cambridge, UK, 1992.

6.1.1.3 Human toxicity

Criticism of the use of MAC values in the CML 1990 method led to the development of a fairly long list of substances that are poisonous to human beings. A notable feature is that human toxicity combines a score for emissions to air, water and soil. The following values have been established for most substances:

- Human-toxicological classification value for air (HCA)
- Human-toxicological classification value for water (HCW)
- Human-toxicological classification values for soil (HCS).

We have not included soil emissions in this because the program does not have an impact category for substances emitted to soil. The number of characterization factors from soil is very limited. Moreover, it may be assumed that emissions that initially enter the soil will ultimately appear in the groundwater and hence can be dealt with as emissions to water.

We have added a number of values for groups to this class: metallic ions and various groups of hydrocarbons. Metallic ions have been given a value equal to that of iron. The values of the hydrocarbons are given in Table **6**. An equivalent has also been selected for most other values that were not defined; e.g. for chlorine, the equivalent value of bromine has been used.

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[4] World Meteorological Organization, *Scientific assessment of ozone depletion 1991*, Global Ozone Research and Monitoring Project - Report no. 25, 1991.

	equivalents			
substances	human toxicity	human toxicity	ecotoxicity	smog
	air	water	water	air
CxHy	isopropanol	isopropanol	crude oil	aliphatics average
CxHy aliphatic	isopropanol	isopropanol	crude oil	aliphatics average
CxHy aromatic	benzene	benzene	benzene	aromatics average
CxHy chloro	1,2, dichloroethane	1,2, dichloroethane	1,2, dichloroethane	average chlorinated org. compounds
PAH	benzo(a)pyrene	benzo(a)pyrene	benzo(a)pyrene	aromatics average

Table 6: Substances from which HCA/HCW, ECA and POCP values for hydrocarbons are taken.

The human toxicity effect score is calculated as follows:

Human toxicity (kg) = (HCA ($kg.kg^{-1}$) x emission to air (kg) +

HCW ($kg.kg^{-1}$) x emission to water (kg))[5]

6.1.1.4 Ecotoxicity

Substances in this class are given values for toxicity to flora and fauna. The main substances are heavy metals. Values have been established for emissions to water and to soil, i.e.:

- Aquatic ecotoxicity (ECA)
- Terrestrial ecotoxicity (ECT)

Only the ECA values have been included in the CML 92 method because emissions to soil eventually appear in the groundwater and are thus already covered.

We have added a number of values for groups of hydrocarbons to this class. Values for the hydrocarbons are shown in Table **6**. An equivalent has been selected for most other values that were not defined.

The effect score for ecotoxicity is calculated as follows:

[5] Vermeire, T.G et al., *Voorstel voor de humaan-toxicologische onderbouwing van C - (toetsings)waarden* [Proposal for the human-toxicological basis of test values], RIVM, Bilthoven, The Netherlands, 1991.

Ecotoxicity (m^3) = (ECA (m^3. kg-1) x waterborne emission (kg))[6]

6.1.1.5 Smog

The photochemical ozone creation potential (POCP) indicates the potential capacity of a volatile organic substance to produce ozone. Values have been published for a wide range of volatile organic substances. The value for ethene has been set at 1. The values for most other substances are less than this. The POCP of these sum-parameters such as alcohols, ketones, aldehydes and various groups of hydrocarbons groups is the average of all the relevant substances in the CML (1992) list. The values for the hydrocarbon groups are given in Table **6**. NO_x is omitted in the CML 92 method.

The effect score for smog is calculated as follows:

Smog (kg) = (POCP x airborne emission (kg))[7]

6.1.1.6 Acidification

The Acidification Potential (AP) is expressed relative to the acidifying effect of SO_2. Other known acidifying substances are nitrogen oxides and ammonia. SO_x has been added, with the same value as SO_2.

Acidification effect scores are calculated as follows:

Acidification (kg) = (AP x airborne emission (kg))

Note that the results of the acidification classes from CML (1990) and CML (1992) are not calculated in the same way.

6.1.1.7 Eutrophication

The Nutrification Potential (NP) is set at 1 for phosphate (PO_4). Other emissions also influence eutrophication, notably nitrogen oxides and ammonium.

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[6] Slooff, W., *Maximum tolerable concentrations, eco-toxicological effect assessment*, RIVM no. 719102018, Bilthoven, The Netherlands.

[7] Protocol to the convention on long-range transboundary air pollution concerning the control of emissions of volatile organic compounds or their transboundary fluxes, United Nations - Economic Commission for Europe (UNECE), Geneva, Switzerland, 1991.

The eutrophication effect score is calculated as follows:

Eutrophication (kg) = (NP x airborne emission (kg))

6.1.1.8 Odour

Weighting factors for stench have been developed, although their use is unusual in LCAs. In these, ammonia is given the value 1.

This class is not included in the CML 92 method because it is a highly localized environmental effect, and the degree of stench nuisance depends largely on local circumstances.

6.1.1.9 Solids

This class is not included in the original CML 1992 classification. We have added the solids class to the method because solid emissions form an important environmental problem in their own right. The weight of the waste emission is used for calculation, and no weighting factors are involved.

Solids (kg) = (solid emission output (kg))

6.1.2 Normalization

The first and probably most widely used normalization set was published in 1993 by Guinée from the CML. This set was compiled by extrapolating 1988 data from the Dutch Emission Registration. Most of the data was simply multiplied by a factor 100, to extrapolate them to the world level, as The Netherlands contribute about 1% to the Gross National Product figures in the World. An exception was made for greenhouse and ozone depleting emissions. These were taken directly from IPCC. The figures are supposed to reflect the world emissions. In order to make the figures more manageable, we have divided them by the world population of 6.000.000.000. A very recent project executed by IVAM-ER, NWS (University of Utrecht) and PRé, under commission from VROM and RIZA, in the Netherlands has resulted in three new sets of normalization figures. They are for a large part based on the Emission registration (base year 1994), and several other sources. The results of this project have been peer reviewed by Guinée. The normalization levels are:

- Dutch territory. All emissions registered emitted within the Netherlands and all raw materials consumed by the Dutch economy.

- Dutch consumer. The effect of imports have been added, the effects of exports have been subtracted. The calculation was performed using the Dutch input-output matrix.
- European territory (EC, Switzerland, Austria and Norway). Most data are from original European data. In some cases data was extrapolated from Dutch and Swiss data. The energy consumption within a region was taken as a basis for extrapolation.

6.1.3 Evaluation

Although several organizations have developed evaluation factors using panel methods, there is no generally recognized method to evaluate the results obtained with the CML method.

6.2 Eco-indicator 95

Eco-indicator 95 is adapted for SimaPro 8. All characterization factors in this method are entered for the 'unspecified' sub-compartment of each compartment (Raw materials, air, water, soil) and thus applicable on all sub-compartments.

This method is NOT fully adapted for inventory data from the Ecoinvent library and the USA Input Output Database 98, and therefore omits emissions that could have been included in impact assessment.

Due to continual adjustments of the method and/or inventory data sets the Eco-indicator 95 in SimaPro 8 will not give the same result as the original printed version.

6.2.1 Characterization

The only difference between the characterizations in the SimaPro 2 CML and SimaPro 3 Eco-indicator 95 methods is in the ecotoxicity and human toxicity effect definition. Both toxicity scores have been replaced by:

- Summer smog (already available in the SimaPro 2 CML method)
- Winter smog
- Carcinogens
- Heavy metals to air and water
- Pesticides

The characterization values are based on the following data:

6.2.1.1 Effect score of persistent toxic substances in air and water

This effect score relates in particular to heavy metals because long-term exposure at low levels brings clear health risks. The risks relate particularly to the nervous system and the liver and can be assessed for toxicity to both human beings and ecosystems. It is assumed in general (Globe, Air Quality Guidelines) that human toxicity is the most important limiting factor. The Air Quality Guidelines specify the following admissible air concentrations for annual exposure to humans (Table **7**).

	Maximum concentration (µg/m³)	**Weighting factor**	**Main health effect**
Cadmium	0.02	50	Kidneys
Lead	1	1	Blood biosynthesis, nervous system and blood pressure
Manganese	7	0.14	Lungs and nervous system (shortage cause skin complaints)
Mercury	1	1	Brain: sensory and co-ordination functions

Table 7: Air Quality Guidelines admissible air concentrations for annual exposure to humans

Chromium and nickel are regarded as carcinogens because the risk of cancer is greater than the toxicological effect.

Based on this concentration a weighting factor can be determined which is equal to the inverse of the admissible concentration. This agrees with the critical volume approximation that used to be applied with the MAC value. We have expressed the effect score as a lead equivalent.

The WHO 'Quality guidelines for drinking water' specify a number of values for persistent substances based on long-term, low-level exposure. These criteria have been drawn up to evaluate drinking water, based on established health effects. In table 8, a selection of substances that are persistent to a greater or lesser extent and that therefore accumulate in the environment.

Substance	Norm (mg/liter)	Weighting factor	Effect
Antimony	0.005	2	Glucose and cholesterol content of blood
Arsenic	0.01	1	Probability of skin cancer $6*10^{-4}$
Barium	0.07	0.14	Blood pressure and blood vessels
Boron	0.3	0.03	Fertility
Cadmium	0.003	3	Kidneys
Chromium (all)	0.05	0.2	Heredity (carcinogenity only applicable in event of inhalation)
Copper	2	0.005	Generally no problems, sometimes liver abnormalities
Lead	0.01	1	Blood biosynthesis, nervous system and blood pressure
Manganese	0.5	0.02	Nervous system
Mercury	0.001	10	Kidneys, nervous system (methyl mercury)
Molybdenum	0.07	0.14	No clear description
Nickel	0.02	0.5	Weight loss, great uncertainty

Table 8: WHO based substances that are persistent

With this effect score the weighting factor is determined in order to be able to calculate the lead equivalent. SimaPro merges the scores for water and air. This is possible because they are both expressed as a lead equivalent and because the target reductions for air and water are the same. We have combined the two scores for heavy metals. This was possible since they are both expressed as a lead equivalent and since the weighting factors are identical.

*Heavy metal to air (kg lead eq.) = (AQG (lead)/AQG (substance) * emission)*

Heavy metal to water (kg lead eq.) = (GDWQ (lead)/GDWQ (substance) emission)*

6.2.1.2 Carcinogenic substances

The 'Air Quality Guidelines' do not specify acceptable levels, but calculate the probability of cancer at a level of 1 µg/m³. In Table **9** this probability is expressed as the number of people from a group of 1 million who will develop cancer with the stated exposure.

	Probability of cancer at 1 µg/m³	Weighting factor for PAH equivalent	Type of cancer
Arsenic	0.004	0.044	General, also mutagenic effects
Benzene	0.000001	$1.1 * 10^{-5}$	Leukemia
Nickel	0.04	0.44	Lung and larynx
Chromium (VI)	0.04	0.44	Lung, among others, and mutagenic effects
PAHs (benzo(a)pyrene)	0.09	1	Lung cancer but also other types of cancer

Table 9: Number of people from a group of 1 million who will develop cancer with the stated exposure.

It is worth considering whether to include asbestos in this list. The difficulty with this is that asbestos emissions cannot be expressed meaningfully in a unit of weight. The number and type of fibers is the determining factor.

It is not entirely clear whether these numbers can be used directly as a weighting factor in order to calculate, for example, a PAH equivalent. This is because it is not known exactly whether a linear correlation may be assumed between probability and exposure. At present we assume that this is so.

Heavy metal to air (kg lead eq.) = (AQG (lead)/AQG (substance))

6.2.1.3 Winter smog

Only dust (SPM) and SO_2 are factors in this problem. For both substances the 'Air Quality Guidelines' specify a level of 50 µg/m³. The weighting factors are thus both 1.

Winter smog (SO_2 or SPM eq.) = SO_2 emission + SPM emission

6.2.1.4 Pesticides

The Globe report describes pesticides as a problem for two reasons:

- Groundwater becomes too toxic for human consumption.
- Biological activity in the soil is impaired, as a result of which vegetation is damaged.

This means that account must be taken in the effect score weighting of both ecotoxicity (soil) and human toxicity (water). The target reduction is based on human toxicity. Globe distinguishes between

- disinfectants
- fungicides
- herbicides
- insecticides

Within these groups all the different sorts are listed, based on their active ingredient content. We propose also doing this for this effect score and shall also list the various mutual categories.

Pesticides (kg) = (active ingredients)

6.2.2 Normalization

The normalization values are based on average European (excluding the former USSR) data from different sources. The reference year is 1990. In many cases we had to extrapolate data from one or more individual countries to the European level. As an extrapolation basis we used the energy consumption of the countries. In order to make the figures more manageable we divided the figures by the population of Europe: 497,000,000.

6.2.3 Evaluation

In the SimaPro 3 and the ecopoints methods the distance-to-target principle is used to calculate evaluation values. The basic assumption is that the seriousness of an impact can be judged by the difference between the current and a target level.

In the SimaPro 3 method the target is derived from real environmental data for Europe (excluding the former USSR), compiled by the RIVM. In the text below this report is referred to as Globe (The Environment in Europe: A Global Perspective).

The targets are set according to the following criteria:

- At target level the effect will cause 1 excess death per million per year
- At target level the effect will disrupt fewer than 5% of the ecosystems in Europe
- At target level the occurrence of smog periods is extremely unlikely

6.2.3.1 Greenhouse effect

At present, temperatures are rising by 0.2% every ten years. Under the current policy this rate will increase to 0.3% every ten years. The consequence will be a large temperature change by 2050. In Northern and Eastern Europe the winters will be more than 5°C warmer, and in Southern Europe the summers will be 4°C warmer. Areas in particular that have no other systems in their vicinity that can exist in such climatic conditions will suffer serious damage. This will affect approximately 20% of Europe.

The Globe report indicates that fewer than 5% of the ecosystems will be impaired if the greenhouse effect is reduced by a factor of 2.5.

6.2.3.2 Ozone layer depletion

In accordance with the Montreal Protocol and its London amendment all CFC emissions must be reduced to zero. For the less persistent HCFCs it has been agreed that the contribution to the effect in 1989 may not exceed 2.6% of the total adverse effect of CFCs. After this, the use of these substances too is to be reduced gradually by 2015.

If that happens the annual total of fatalities per million inhabitants in Europe will first rise from approximately 1 to 2 and then fall to 1 death per year per million inhabitants. It does not yet seem directly necessary to reduce all HCFC emissions to zero because the norm (2 ppbv) is going to be achieved, even if after 2100. For these gases the target reduction is linked to the greenhouse effect[8].

Based on this reduction for greenhouse gases, we therefore assume, for the moment, that the target reduction for HCFCs is of the order of 60%. Based on the premise that the HCFCs presently cause 2.6% of ozone layer depletion it can be estimated that this reduction will cause ozone layer depletion to fall to 1% of its present level. The reduction factor is thus 100. There is a great deal of uncertainty about this figure.

[8] By contrast, the elimination of CFCs will also result in a significant reduction in the greenhouse effect. CFCs are responsible for 24% of this effect. Eliminating the CFCs will therefore yield a 24% reduction in the greenhouse effect.

6.2.3.3 Acidification

There is a great variety in Europe in the ability of ecosystems to withstand acidification. In Scandinavia, for example, problems can occur with deposits of 100 eq/ha.yr, while in some places in the Netherlands and Germany the soil can withstand a deposit of more than 2000 eq/ha.yr.

Actual deposition appears to reach its highest level in Central Europe, particularly as a result of the use of lignite.

If the deposition and ability to withstand acidification are combined with each other, it seems that major problems are occurring particularly in England, the Benelux countries, Germany, Poland, the Czech Republic and Slovakia.

A provisional estimate based on the RAINS computer model shows that the reduction must be of the order of a factor of 10 to 20 to keep damage to the ecosystem below 5%.

6.2.3.4 Eutrophication

Eutrophication is seen in the Globe report particularly as the problem of excessive use of fertilizers by agriculture, as a result of which nitrates leach out and poison groundwater supplies. The problem is at its greatest in the Benelux countries, North-Rhine Westphalia (Germany) and Italy's Po valley plain (approx. 200 kg/ha).

In the CML classification Eutrophication refers mainly to air and water emissions. These rarely contribute more than 10% of the amount of fertilizer applied by farmers. In uncultivated biotopes, however, that are low in nutrients this eutrophication can have a serious adverse effect on biodiversity.

In describing the level of eutrophication in rivers and lakes it is estimated that the critical value for phosphates is 0.15 mg/l and for nitrates 2.2 mg/l. At these levels there are no problems with eutrophication. In the rivers Rhine, Schelde, Elbe, Mersey and Ebro, however, these figures have been exceeded more than 5 times. This means that the emissions must be reduced by a factor 5.

6.2.3.5 Summer smog

A hundred years ago the ozone concentration averaged over the whole year was approximately 10 ppb. At present it is 25 ppb. This is approximately the maximum acceptable level; above 30 ppb, for example, crop damage can occur.

The major problem is not determined by the average figures but by the summer peaks which can reach more than 300 ppb. To reduce this type of dangerous peak by 90% it is necessary to reduce VOCs and NO_x by 60 to 70%.

6.2.3.6 Heavy metals

In Central Europe lead concentrations are very high, particularly in the soil and water. The air concentration is also high in towns and cities, particularly because of the use of leaded petrol. For adults the Air Quality Guideline specifies a limit in the air of 0.5 to 1 µg/m³. According to Globe this value is often exceeded by a number of times. Globe notes in passing (and without backing it up) that average lead concentrations in Poland are 20 µg/m³.

Eating locally grown vegetables would result in a blood lead level that is ten times too high. Lead levels in children's blood of 150 to 400 µg/l have been found. Such readings also occurred in the West 30 years ago, but not anymore. The figures are five to ten times lower now. There is thought not to be a no-effect-level for exposure for children. Above 100 µg/l clear reductions in learning ability can be measured.

Thus although it is plausible that this pollution has a clearly measurable effect on human health, it is not easy to calculate a general reduction percentage for lead. The best estimate is a reduction by a factor of 5 to 10. We have taken a figure of 5 for heavy metal emissions to air.

Agriculture (fertilizer) is the major source of cadmium deposition. The average deposition rate is 0.6 to 0.67 g/ha on grassland and 3.4 to 6.8 g/ha for arable land. The Southern Netherlands holds the record with a deposition rate of 7.5 to 8.5 g/ha. Furthermore, approximately 14% is distributed via the air (see winter smog).

This leaching is calculated in the Globe report for the Rhine. A detailed calculation makes a convincing case for the necessity to reduce cadmium emissions by 80 to 85%. In some other rivers such as the Elbe cadmium contamination is substantially greater, and the required target will perhaps have to be set even higher. For the moment we are continuing with a target reduction of a factor of 5 for heavy metals in water.

6.2.3.7 Winter smog

The most important sources of this problem which occurs mainly in Eastern Europe are SO_2 and SPM (suspended particle matter, or small dust and soot particles). NO_x, organic substances and CO are also involved to a lesser extent. The dust particles can also contain heavy metals.

This form of smog achieved notoriety in 1952 when it caused an estimated 4000 deaths in London. The SO_2 and SPM concentrations reached values of 5000 micrograms per cubic meter. In Southern Poland and Eastern Germany average readings of 200µg/m³ still occur repeatedly. The Air Quality Guidelines specify a limit of 50µg/m³ for long-term exposure to both SPM and SO_2. Based on this, a reduction of 75% would be necessary.

Globe estimates that a reduction in SO_2 emissions of more than 80% is necessary to eliminate by and large the occurrence of occasional smog periods. No target is proposed for SPM because it is not well a defined or well measured[9] pollutant.

We are continuing to use a factor of 5 as a target.

6.2.3.8 Carcinogenic substances

Globe also provides some data on the distribution of carcinogenic substances. The main substances involved are polyaromatic hydrocarbons (PAHs), of which benzo[a]pyrene in particular is an important example. This occurs, among other places, in coke furnaces and in (diesel) motors. In fact, the problem is only relevant in urban areas.

Globe specifies a value of 0.8 to 5 ng/m³ for Northern European towns and cities. The Air Quality Guideline specifies a value of 1 ng/m³ in American cities without coke furnaces in the vicinity and 1 to 5 ng/m³ in cities with coke furnaces. In European towns and cities in the 60s, when open coal fires were still very much in use, the average concentrations were in excess of 100 ng/m³. In Eastern Europe the values are still high because of the use of coal-fired heating systems. As a point of comparison, a room in which a lot of smoking takes place can contain 20 ng/m³.

The Air Quality Guideline specifies a threshold concentration of 0.01 ng/m³ at which 1 cancer case per million inhabitants per year will still occur. This criterion cannot be compared straightforwardly with the criterion for ozone layer depletion because not all the cancer cases are terminal. In addition, only about 1/3 of the population of Europe lives in towns or cities[10]. If we assume that one in every three cancer cases is terminal and if we only take the urban population the risk of death is about ten times lower. Based on this, there would be one death per million inhabitants per year at a concentration of 0.1 ng/m³.

Based on a background concentration of 1 ng/m³ in towns and cities without coke furnaces (West European towns and cities in particular) a reduction by a factor of 10 could be estimated.

6.2.3.9 Pesticides

Leaching of pesticides threatens groundwater sources throughout the EU. The groundwater is contaminated in 65% of the EU above the EU norm (0.5 µg/liter). The norm is exceeded tenfold in 25% of the EU. This occurs in 20% of the land area of Eastern Europe. A reduction by a factor of 25 is necessary to ensure that the norm is exceeded in less than 10% of Europe.

[9] A major shortcoming of the CML classification system is the lack of a weighting factor for particulate matter in calculating human toxicity. According to the Globe report, SPM is one of the most injurious substances to health.

[10] Eurostat, estimate based on data for 6 EU member states

6.2.3.10 Exhaustion of raw materials and solid waste

We have not defined any percentage reductions for exhaust of raw materials. There are two reasons for this:

No people die and no ecosystems are impaired as a result of the depletion of raw materials. It mainly causes economic and social problems.

Exhaustion is difficult to quantify because there are alternatives for most materials. For example, copper has already been replaced on a very wide scale by glass-fiber (communications) and aluminum (electricity-conducting medium). There are also good prospects for substituting materials in energy generation if the market is prepared to pay more for energy. In fact, the problem with energy is not the depletion of fossil fuels but the environmental impacts of combustion. Explicit account is taken of these in the indicator. In other words, you need not think that all the oil reserves that are presently known have actually been used. That would be an environmental disaster.

We have not defined any percentage reduction for waste. A similar reason applies to waste as to energy. No people die and only very small sections of ecosystems are threatened by the use of space for waste (apart from litter or fly-tipped waste). Emissions from incineration, the decomposition of waste and the leaching of, for example, heavy metals are major problems. These emissions are properly specified in a good LCA. Waste is thus included in similar fashion, but it is assessed in terms of its emissions.

We do not have any score for ecotoxicity and human toxicity, as is usually the case. Instead we have a score for carcinogenic substances, heavy metals, winter smog and pesticides. The reason for this is that we could not find any reduction target for such a vague concept. We therefore opted to specify the term "toxicity" in individual problems.

As a result of these changes, the Eco-indicator can be viewed as an indicator for emissions, and raw materials exhaustion and the use of space for waste must be assessed individually for the moment. Despite this limitation we feel that the indicator is a powerful tool. Emissions will be our greatest concern if we wish to protect health and ecosystems.

6.2.4 Summary of weighting factors

Table **10** summarizes the values and the criteria used in determining them. The choice of these criteria is very important because there is a direct correlation with the reduction factors. If 5% ecosystem damage is compared with ten deaths per year rather than one, then all reduction factors based on the number of deaths criterion will fall by a factor of ten, assuming there is a linear correlation between an effect and the number of deaths.

Table **10** gives you an opportunity to calculate other weightings for yourself if you wish to use different criteria.

	Characterization	**Reduction factor**	**Criterion**
Greenhouse	CML (IPCC)	2.5	0.1° per decade, 95th percentile?
Ozone layer	CML (IPCC)	100	Probability of 1 death per year per million inhabitants
Acidification	CML	10	95th percentile
Eutrophication	CML	5	Rivers and lakes damage to an unknown number of aquatic ecosystems? (95th percentile?)
Summer smog	CML	2.5	Prevent smog periods, health complaints, particularly amongst asthma patients and the elderly
Winter smog	Air Quality Guidelines	5	Prevent smog periods, health complaints, particularly amongst asthma patients and the elderly
Pesticide	Active ingredient	25	95th percentile ecosystems
Heavy metals in air	Air Quality Guidelines	5	Lead content in blood of children, limited life expectancy and learning performance in an unknown number of people
Heavy metals in water	Quality Guidelines for water	5	Cadmium content in rivers, ultimately also has an effect on people (see air)
Carcinogenic substances	Air Quality Guidelines	10	Probability of 1 death per year per million inhabitants

Table 10: Background weighting factors.

6.3 Eco-indicator 99

Eco-indicator 99 is the successor of Eco-indicator 95. Both methods use the damage-oriented approach. The development of the Eco-indicator 99 methodology started with the design of the weighting procedure. Traditionally in LCA the emissions and resource extractions are expressed as 10 or more different impact categories, like acidification, ozone layer depletion, ecotoxicity and resource extraction. For a panel of experts or non-experts it is very difficult to give meaningful weighting factors for such a large number and rather abstract impact categories. It was concluded that the panel should not be asked to weight the impact categories but the different types of damage that are caused by these impact categories. The other improvement was to limit the number of items that are to be assessed. As a result the panel, consisting of 365 persons from a Swiss LCA interest group, was asked to assess the seriousness of three damage categories:

1. Damage to Human Health, expressed as the number of year life lost and the number of years lived disabled. These are combined as Disability Adjusted Life Years (DALYs), an index that is also used by the World bank and WHO.
2. Damage to Ecosystem Quality, express as the loss of species over an certain area, during a certain time
3. Damage to Resources, expressed as the surplus energy needed for future extractions of minerals and fossil fuels.

In order to be able to use the weights for the three damage categories a series of complex damage models had to be developed. In Figure 4 these models are represented in a schematic way.

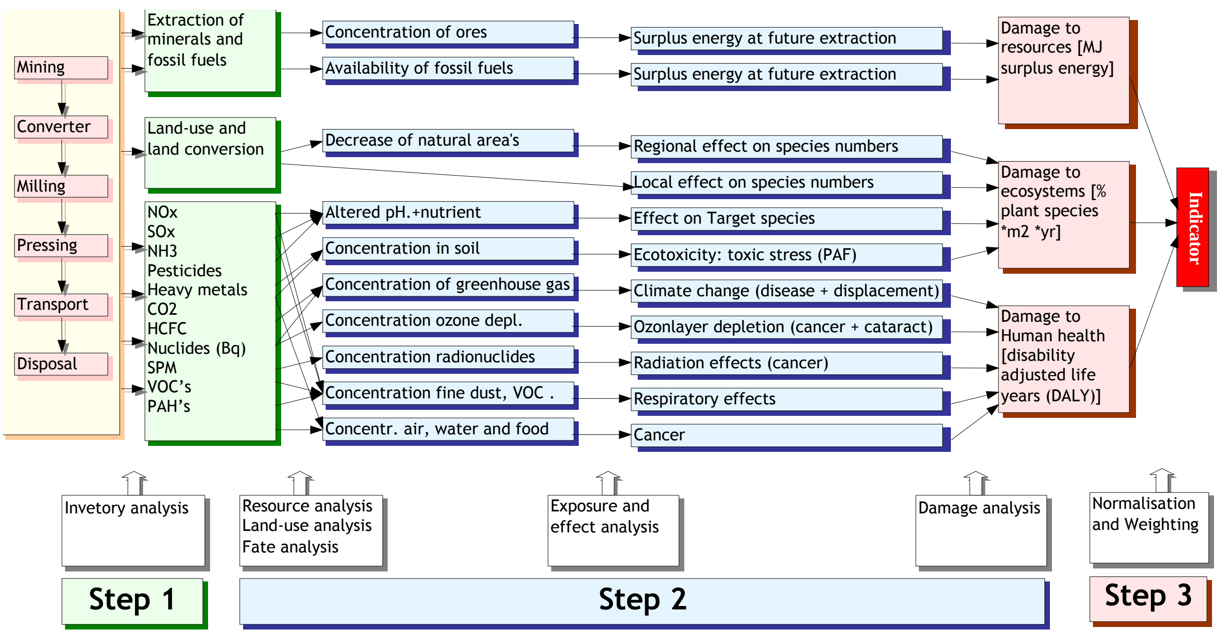

Figure 4 Detailed representation of the damage model

In general, the factors used in SimaPro do not deviate from the ones in the (updated) report. In case the report contained synonyms of substance names already available in the substance list of the SimaPro database, the existing names in the database are used. A distinction is made for emissions to agricultural soil and industrial soil, indicated with respectively (agr.) or (ind.) behind substance names emitted to soil.

6.3.1 Characterization

6.3.1.1 Emissions

Characterization is factors are calculated at end-point level (damage). The damage model for emissions includes fate analysis, exposure, effects analysis and damage analysis.

This model is applied for the following impact categories:

Carcinogens

Carcinogenic affects due to emissions of carcinogenic substances to air, water and soil. Damage is expressed in Disability adjusted Life Years (DALY) / kg emission.

Respiratory organics

Respiratory effects resulting from summer smog, due to emissions of organic substances to air, causing respiratory effects. Damage is expressed in Disability adjusted Life Years (DALY) / kg emission.

Respiratory inorganics

Respiratory effects resulting from winter smog caused by emissions of dust, sulphur and nitrogen oxides to air. Damage is expressed in Disability adjusted Life Years (DALY) / kg emission.

Climate change

Damage, expressed in DALY/kg emission, resulting from an increase of diseases and death caused by climate change.

Radiation

Damage, expressed in DALY/kg emission, resulting from radioactive radiation

Ozone layer

Damage, expressed in DALY/kg emission, due to increased UV radiation as a result of emission of ozone depleting substances to air.

Ecotoxicity

Damage to ecosystem quality, as a result of emission of ecotoxic substances to air, water and soil. Damage is expressed in Potentially Affected Fraction (PAF)*m^2*year/kg emission.

Acidification/ Eutrophication

Damage to ecosystem quality, as a result of emission of acidifying substances to air. Damage is expressed in Potentially Disappeared Fraction (PDF)* m^2*year/kg emission.

6.3.1.2 Land use

Land use (in manmade systems) has impact on species diversity. Based on field observations, a scale is developed expressing species diversity per type of land use. Species diversity depends on the type of land use and the size of the area. Both regional effects and local effects are taken into account in the impact category:

Damage as a result of either conversion of land or occupation of land. Damage is expressed in Potentially Disappeared Fraction (PDF)* m^2*year/ m^2 or m2a.

6.3.1.3 Resource depletion

Mankind will always extract the best resources first, leaving the lower quality resources for future extraction. The damage of resources will be experienced by future generations, as they will have to use more effort to extract remaining resources. This extra effort is expressed as “surplus energy”.

- **Minerals**

  Surplus energy per kg mineral or ore, as a result of decreasing ore grades.

- **Fossil fuels**

  Surplus energy per extracted MJ, kg or m^3 fossil fuel, as a result of lower quality resources.

6.3.2 Uncertainties

Of course it is very important to pay attention to the uncertainties in the methodology that is used to calculate the indicators. Two types are distinguished:

1. Uncertainties about the correctness of the models used
2. Data uncertainties

Data uncertainties are specified for most damage factors as squared geometric standard deviation in the original reports, but not in the method in SimaPro. It is not useful to express the uncertainties of the model as a distribution. Uncertainties about the model are related to subjective choices in the model. In order to deal with them we developed three different versions of the methodology, using the archetypes specified in Cultural Theory. The three versions of Eco-indicator 99 are:

1. the egalitarian perspective
2. the hierarchist perspective
3. the individualist perspective

6.3.2.1 Hierarchist perspective

In the hierarchist perspective the chosen time perspective is long-term, substances are included if there is consensus regarding their effect. For instance all carcinogenic substances in IARC class 1, 2a and 2b are included, while class 3 has deliberately been excluded. In the hierarchist perspective damages are assumed to be avoidable by good management. For instance the danger people have to flee from rising water levels is not included. In the case of fossil fuels the assumption is made that fossil fuels cannot easily be substituted. Oil and gas are to be replaced by shale, while coal is replaced by brown coal. In the DALY calculations age weighting is not included.

6.3.2.2 Egalitarian perspective

In the egalitarian perspective the chosen time perspective is extremely long-term, Substances are included if there is just an indication regarding their effect. For instance all carcinogenic substances in IARC class 1, 2a, 2b and 3 are included, as far as information was available. In the egalitarian perspective, damages cannot be avoided and may lead to catastrophic events. In the case of fossil fuels the assumption is made that fossil fuels cannot be substituted. Oil, coal and gas are to be replaced by a future mix of brown coal and shale. In the DALY calculations age weighting is not included.

6.3.2.3 Individualist perspective

In the individualist perspective the chosen time perspective is short-term (100 years or less). Substances are included if there is complete proof regarding their effect. For instance only carcinogenic substances in IARC class 1 included, while class 2a, 2b and 3 have deliberately been excluded. In the individualist perspective damages are assumed to be recoverable by technological and economic development. In the case of fossil fuels the assumption is made that fossil fuels cannot really be depleted. Therefore they are left out. In the DALY calculations age weighting is included.

6.3.3 Damage assessment

Damages of the impact categories result in three types of damages:

1. Damage to **Human Health**, expressed as the number of year life lost and the number of years lived disabled. These are combined as Disability Adjusted Life Years (DALYs), an index that is also used by the World Bank and the WHO.

2. Damage to **Ecosystem Quality**, express as the loss of species over an certain area, during a certain time

3. Damage to **Resources**, expressed as the surplus energy needed for future extractions of minerals and fossil fuels.

6.3.4 Normalization

Normalization is performed on damage category level. Normalization data is calculated on European level, mostly based on 1993 as base years, with some updates for the most important emissions.

6.3.5 Weighting

In this method weighting is performed at damage category level (endpoint level in ISO). A panel performed weighting of the three damage categories. For each perspective, a specific weighting set is available. The average result of the panel assessment is available as weighting set.

The hierarchist version of Eco-indicator 99 with average weighting is chosen as default. In general, value choices made in the hierarchist version are scientifically and politically accepted.

6.4 Ecopoints 97

The Swiss Ministry of the Environment (BUWAL) has developed the Ecopoint system, based on actual pollution and on critical targets that are derived from Swiss policy. It is one of the earliest systems for impact assessment with a single score. Like the Eco-indicator 95 method, described above, it is based on the distance-to-target method. The Swiss Ecopoints 1997 (also called Swiss ecoscarcity) is an update of the 1990 method.

There are three important differences:

1. The Ecopoint system does not use a classification. It assesses impacts individually. Although this allows for a detailed and very substance-specific method, it has the disadvantage that only a few impacts are assessed.

2. The Ecopoint system uses a different normalization principle. It uses target values rather than current values.

3. The Ecopoint system is based on Swiss policy levels instead of sustainability levels. Policy levels are usually a compromise between political and environmental considerations.

The following data are necessary in calculating a score in ecopoints for a given product:

- quantified impacts of a product;
- total environmental load for each impact type in a particular geographical area;
- maximum acceptable environmental load for each impact type in that particular geographical area.

6.4.1 Normalization

In SimaPro you will find 3 normalization sets: Target; Actual; and Ecopoints.

1) Normalization on Target Value or Critical Emission (N=Target)

   The original formula is used to calculate the Ecopoints:

$$\text{Ecofactor}=\frac{1}{Fk}\times\frac{F}{Fk}\times Const$$

$$\frac{1}{Fk}=\textit{normalization factor}$$

$$\frac{F}{Fk}\times Const=\textit{evaluation factor}$$

2) Normalization based on Actual Emission (N= Actual)

   The adapted formula is used to calculate the Ecopoints so that normalization based on actual emissions can be done:

$$\text{Ecofactor}=\frac{1}{F}\times\frac{F}{Fk}\times\frac{F}{Fk}\times Const$$

$$\frac{1}{F}=\text{normalization factor}$$

$$\frac{F}{Fk}\times\frac{F}{Fk}Const=\textit{evaluation factor}$$

F =*Actual Swiss emission per year*

Fk =*Critical Swiss emission per year Const.=10^{12}/year*

3) Ecopoints

Ecofactors given in the evaluation step, normalization factors=1.

6.4.2 Weighting

Ecopoints (weighting factors) are calculated using the following formula:

$$f = \frac{1}{Fk} \times \frac{F}{Fk} \times 10^{12} = \frac{F}{Fk^2} \times 10^{12}$$

f: ecofactor

F: actual total current load

Fk: target norm for total load

10^{12} constant

The first term (1/Fk) expresses the relative contribution of the load to the exceeding of the target norm. It is the normalization step. The second term (F/Fk) expresses the extent to which the target norm is already being exceeded.

Please note that not all sum parameters such as (heavy) metals, AOX contributants, are included in the method.

<u>References</u>

Braunschweig A. et al. 1998. *Bewertung in Ökobilanzen mit der Methode der ökologischen Knappheit.* Ökofaktoren, Methodik Für Oekobilanzen, Buwal Schriftenreihe Umwelt Nr 297.

6.5 EDIP/UMIP 97

The EDIP method (Environmental Design of Industrial Products, in Danish UMIP) was developed in 1996.

In 2004 the characterization factors for resources, the normalization and weighting factors for all impact categories were updated. Excluded in this version of the method in SimaPro are working environment and emissions to waste water treatment plants (WWTP).

The method is adapted for SimaPro. All characterization factors in this method are entered for the 'unspecified' sub-compartment of each compartment (raw, air, water, soil) and thus applicable on all sub-compartments, where no specific characterization value is specified.

6.5.1 Characterization

Global warming is based on the IPCC 1994 Status report. Is SimaPro GWP 100 is used. Stratospheric ozone depletion potentials are based on the status reports (1992/1995) of the Global Ozone Research Project (infinite time period used in SimaPro). Photochemical ozone creation potentials (POCP) were taken from UNECE reports (1990/1992). POCP values depend on the background concentration of NO_x, in SimaPro we have chosen to use the POCPs for high background concentrations. Acidification is based on the number of hydrogen ions (H+) that can be released. Eutrophication potential is based on N and P content in organisms. Waste streams are divided in 4 categories, bulk waste (not hazardous), hazardous waste, radioactive waste and slags and ashes. All wastes are reported on a mass basis.

Ecotoxicity is based on a chemical hazard screening method, which looks at toxicity, persistency and bio-concentration. Fate or the distribution of substances into various environmental compartments is also taken account. Ecotoxicity potentials are calculated for acute and chronic ecotoxicity to water and chronic ecotoxicity for soil. As fate is included, an emission to water may lead not only to chronic and acute ecotoxicity for water, but also to soil. Similarly an emission to air gives ecotoxicity for water and soil. This is the reason you will find emissions to various compartments in each ecotoxicity category.

Human toxicity is based on a chemical hazard screening method, which looks at toxicity, persistency and bio-concentration. Fate or the distribution of substances into various environmental compartments is also taken account. Human toxicity potentials are calculated for exposure via air, soil, and surface water. As fate is included, an emission to water may lead not only to toxicity via water, but also via soil. Similarly an emission to air gives human toxicity via water and soil. This is the reason you will find emissions to various compartments in each human toxicity category.

As resources use a different method of weighting, it cannot be compared with the other impact categories, for which reason the weighting factor is set at zero. Resources should be handled with great care when analyzing results, the characterization and normalization results cannot be compared with the other impact categories.

To give the user some information in a useful way all resources have been added into one impact category. As equivalency factor the result of the individual normalization and weighting scores have been used, i.e. the resulting score per kg if they would have been calculated individually.

For detailed information on resources, including normalization and weighting, choose the "EDIP/UMIP resources only" method.

EDIP v2.0 resources only

In the "EDIP/UMIP resources only" method only resources are reported. Opposite to the default EDIP/UMIP method, resources are given in individual impact categories, on a mass basis of the pure resource (i.e. 100% metal in ore, rather than ore). Normalization is based on global production per world citizen, derived from World Resources 1992. Weighting of non-renewables is based on the supply-horizon (World Reserves Life Index), which specifies the period for which known reserves will last at current rates of consumption. If no normalization data are known for an individual impact category, the normalization value is set at one and the calculation of the weighting factor is adjusted so that the final result is still consistent. However this may give strange looking graphs in the normalization step.

6.5.2 Normalization

The normalization value is based on person equivalents for 1994 (according to the update issued in 2004). For resources, normalization and weighing are already included in the characterization factor and therefore set at zero.

6.5.3 Weighting

The weighting factors are set to the politically set target emissions per person in the year 2004 (according to the update issued in 2004), the weighted result are expressed except for resources which is based on the proven reserves per person in 1994. For resources, normalization and weighing are already included in the characterization factor and therefore set at zero.

Note:

> *Presenting the EDIP method as a single score (addition) is allowed, however it is not recommended by the authors. Note that due to a different weighting method for resources (based on reserves rather than political targets), resources may never be included in a single score. This is the reason that the weighting factor for resources is set at zero.*

References

Hauschild, M.; Wenzel, H. 1998. *Environmental Assessment of Products. Volume 2: Scientific background.* Chapman and Hall. See http://www.wkap.nl/book.htm/0-412-80810-2.

Wenzel, H.; Hauschild, M.; Alting, L. 1997. *Environmental Assessment of Products. Volume 1: Methodology, tools and case studies in product development.* Chapman and Hall. See http://www.wkap.nl/book.htm/0-7923-7859-8.

6.6 IPCC 2001 GWP

IPCC 2001 is a method developed by the International Panel on Climate Change.

This method lists the climate change factors of IPCC with a timeframe of 20, 100 and 500 years. The method from the ecoinvent 1.01 database was expanded with other characterization factors for emissions available in the SimaPro database.

6.6.1 Characterization

The IPCC characterization factors for the direct global warming potential of air emissions. They are:

- not including indirect formation of dinitrogen monoxide from nitrogen emissions.
- not accounting for radiative forcing due to emissions of NOx, water, sulphate, etc. in the lower stratosphere + upper troposphere.
- not considering the range of indirect effects given by IPCC.
- including CO_2 formation from CO emissions.
- considering biogenic CO_2 uptake as negative impact.

6.6.2 Normalization and weighting

Normalization and weighting are not a part of this method.

References

Intergovernmental Panel on Climate Change (IPCC). 2001. *IPCC Third Assessment Report. The Scientific Basis*.
http://www.grida.no/climate/ipcc_tar/

6.7 IPCC 2007

IPCC 2007 is an update of the method IPCC 2001 developed by the International Panel on Climate Change. This method lists the climate change factors of IPCC with a timeframe of 20, 100 and 500 years.

6.7.1 Characterization

IPCC characterization factors for the direct (except CH_4) global warming potential of air emissions. They are:

- not including indirect formation of dinitrogen monoxide from nitrogen emissions.

- not accounting for radiative forcing due to emissions of NOx, water, sulphate, etc. in the lower stratosphere + upper troposphere.
- not considering the range of indirect effects given by IPCC.
- not including CO_2 formation from CO emissions.
- If only a minimum or maximum value of a substance is reported this minimum or maximum value is used.
- The substances that do not have a common name but only a formula are not included in the method.
- NOT considering biogenic CO_2 uptake and emission, but only considering the biogenic methane release.

6.7.2 Normalisation and weighting

Normalization and weighting are not a part of this method.

References

Intergovernmental Panel on Climate Change. 2007. *IPCC Fourth Assessment Report. The Physical Science Basis*. http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

Intergovernmental Panel on Climate Change. 2007. *IPCC Fourth Assessment Report. The Physical Science Basis*. Errata. http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Errata_2008-08-05.pdf

6.8 EPD (2008)

This method is to be used for the creation of Environmental Product Declarations or (EPDs), as published on the website Swedish Environmental Management Council (SEMC). The last update of this method is mainly based on the EPD document version 1.0 dated 2008-02-29.

6.8.1 Characterization

In the standard EPDs one only has to report on the following impact categories:

Original names	Names in SP
• Gross Calorific Values (GVC) (referred to as "Higher Heating Values")	Non renewable, fossil
• Greenhouse gases	Global warming (GWP100)
• Ozone-depleting gases	Ozone layer depletion (ODP)
• Acidifying compounds	Acidification
• Gases creating ground-level ozone (Photochemical Ozone creation)	Photochemical oxidation
• Eutrophying compounds	Eutrophication

Specific product category guidelines may require extra information.

6.8.2 Non renewable, fossil

The values as used for the calculation of the non renewable, fossil impact category are taken from the Cumulative energy demand LCIA method (v 1.05) as implemented in SimaPro.

Global warming (GWP100)

The values from IPPC (2007) are used as recommended on the EPD website. The characterization for biogenic methane has been corrected for the CO_2 sequestration.

6.8.3 Ozone layer depletion (ODP), Photochemical oxidation, Acidification and Eutrophication

The values as used by the EPD document are used.

6.8.4 Normalization and weighting

Normalization and weighting are not a part of this method.

References

"Revision of the EPD® system into an International EPD®": www.environdec.com/Documents/GPI/EPD_annexes_080229.pdf

We thank Leo Breedveld from 2B (www.to-be.it) for his advice and support.

6.9 Ecological scarcity 2006

The "ecological scarcity" method (also called Ecopoints or Umweltbelastungspunkte method) is a follow up of the Ecological scarcity 1997 method (see section 6.4), named Ecopoints 97 (CH) in the SimaPro method library.

The ecological scarcity method weights environmental impacts - pollutant emissions and resource consumption - by applying "eco-factors". The eco-factor of a substance is derived from environmental law or corresponding political targets. The more the current level of emissions or consumption of resources exceeds the environmental protection target set, the greater the eco-factor becomes, expressed in eco-points (EP). An eco-factor is essentially derived from three elements (in accordance with ISO Standard 14044): characterization, normalization and weighting.

6.9.1 Characterization, normalization and weighting

Characterization captures the relative harmfulness of a pollutant emission or resource extraction vis-à-vis a reference substance within a given impact category (global warming potential, acidification potential, radioactivity etc.). Normalization quantifies the contribution of a unit of pollutant or resource use to the total current load/pressure in a region (in this case the whole of Switzerland) per year. Weighting expresses the relationship between the current pollutant emission or resource consumption (current flow) and the politically determined emission or consumption target (critical flow).

The Ecoinvent implementation contains seven specific impact categories, with for each substance a final UBP (environmental loading points) score as characterization factor which compile the characterization, normalization and distance-to-target weighting. The impact categories considered by this method are not defined as an impact indicator but rather as type of emission or resource:

- Emissions into air
- Emissions into surface water
- Emissions into ground water
- Emissions into top soil
- Energy resources
- Natural resources
- Deposited waste

References

Frischknecht, R.; Steiner, R.; Jungbluth, N. 2008. *Methode der ökologischen Knappheit - Ökofaktoren 2006*. Öbu SR No. 28/2008, Bundesamt für Umwelt (BAFU), ÖBU Schweizerische Vereinigung für ökologisch bewusste Unternehmungsführung, Zürich und Bern.

Frischknecht, R.; Jungbluth, N.; Althaus, H.J.; Doka, G.; Dones, R.; Hischier, R.; Hellweg, S.; Humbert, S.; Margni, M.; Nemecek, T.; Spielmann, M. 2007. *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* ecoinvent report No. 3, Swiss centre for Life Cycle Inventories, Dübendorf, Switzerland.

Frischknecht, R.; Steiner, R.; Braunschweig, A.; Egli, N.; Hildesheimer, G. 2006. *Swiss Ecological Scarcity Method: The New Version 2006*. Available at http://www.esu-services.ch/fileadmin/download/Frischknecht-2006-EcologicalScarcity-Paper.pdf.